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Feeding Experiments with Ground-nut Oil-cake.

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The first of this series of experiments was started on the Rayanakere Dairy Farm in July 1921. Twenty calves were selected for the purpose and divided into two lots of ten animals each. One lot was fed on wheat bran, and the other lot on bran and ground-nut oil-cake, coarse fodder such as straw, green grass or silage being the same for all the animals. The first period of feeding was closed on 15th October 1921, and the results obtained have been published in detail in Vol. IV, No. 1 of this Journal. The work was continued further till January 1923. The animals were weighed on three consecutive days every fortnight and the monthly weights are given in Tables I and II. Table III gives the weights of the various groups of animals at the end of each quarter from the beginning of the experiment, and the increase in weight during the same period.

TABLE I.

Giving monthly weights in lbs. of animals under feeding experiments.

"B" Number calves. Bran and Cake Series.

Calf No.	Sex	13th July 1921	15th Oct. 1921	17th Dec. 1921	17th Jan. 1922	15th Feb. 1922	16th Mar. 1922	15th Apr. 1922	17th May 1922	15th June 1922	15th July 1922	29th July 1922	19th Aug. 1922	16th Sept. 1922	12th Oct. 1922	12th Nov. 1922	9th Dec. 1922	6th Jan. 1923	Total increase
1	Heifers	..	..	292	320	337	357	359	372	394	424	424	451	467	486	497	513	536	
3		..	..	296	315	332	350	353	358	371	402	408	424	448	468	483	508	536	
5		..	..	321	343	358	351	366	370	393	436	437	461	477	486	499	527	548	
9		..	..	260	270	295	311	327	336	367	398	409	428	446	465	481	506	519	
23		..	..	344	347	368	389	403	392	404	446	446	470	482	499	513	528	557	
Total		1099	1444	1513	1595	1690	1758	1808	1828	1929	2106	2124	2234	2320	2404	2473	2582	2696	
Increase		..	345	69	82	95	68	50	20	101	177	18	110	86	84	69	109	114	1597
15	Bulls	..	..	339	358	363	377	386	381	393	439	448	475	489	509	509	536	555	
17		..	..	329	361	381	389	399	411	421	469	482	497	522	560	571	599	615	
18		..	..	285	315	335	365	382	393	428	477	478	512	536	567	579	622	632	
19		..	..	338	369	386	405	414	418	438	482	479	517	530	564	585	614	635	
20		..	..	311	327	340	326	323	303	322	347	347	361	353	374	384	393	401	
Total		1195	1577	1602	1730	1805	1862	1904	1906	2002	2214	2234	2362	2430	2574	2628	2764	2838	
Increase		..	382	25	128	75	57	42	2	96	212	20	128	68	144	54	136	74	1643
Grand total (10 calves)		2294	3021	3115	3325	3495	3620	3712	3734	3931	4320	4358	4596	4750	4978	5101	5346	5534	
Increase		..	727	94	210	170	125	92	22	197	389	38	238	154	228	123	245	188	3240

Inoculated against black quarter on 21—7—1922.

New feeding started on 5—8—1922.

TABLE II.

Giving monthly weights in lbs. of animals under feeding experiments.

"B" Number calves. Bran Series.

Calf No.	Sex.	13th July 1921	15th Oct. 1921	17th Dec. 1921	17th Jan. 1922	15th Feb. 1922	16th Mar. 1922	15th Apr. 1922	17th May 1922	15th June 1922	15th July 1922	29th July 1922	19th Aug. 1922	16th Sept. 1922	12th Oct. 1922	12th Nov. 1922	9th Dec. 1922	6th Jan. 1923	Total increase
2	Heifers	..	..	326	346	360	364	380	387	398	434	456	467	489	518	529	566	572	
8		..	..	225	239	251	262	272	279	302	341	347	370	383	410	427	440	440	
11		..	..	268	292	303	316	311	321	337	363	370	394	407	428	443	462	473	
12		..	..	277	298	321	531	336	342	369	398	410	423	441	462	474	493	507	
26		..	..	328	365	379	407	402	403	432	472	481	501	517	535	544	578	584	
Total		1124	1382	1424	1540	1614	1680	1701	1732	1838	2008	2064	2155	2237	2353	2417	2539	2576	
Increase		..	258	42	116	74	66	21	31	106	170	56	91	82	116	64	122	37	1452
10	Bulls	..	..	301	328	345	370	378	381	413	449	471	481	503	518	541	561	571	
16		..	..	324	340	357	368	380	389	419	455	466	489	505	538	553	576	584	
22		..	..	324	351	360	385	401	416	444	472	478	496	518	555	571	587	607	
25		..	..	327	350	369	400	408	414	452	497	517	535	551	568	526	544	544	
27		..	..	264	279	294	303	308	312	334	361	365	387	397	420	427	446	451	
Total		1177	1455	1520	1648	1725	1826	1875	1912	2062	2234	2297	2388	2474	2599	2618	2714	2757	
Increase		..	278	65	128	77	101	49	37	150	172	63	91	86	125	19	96	43	1580
Grand total (10 calves)		2301	2837	2944	3188	3339	3506	3576	3644	3900	4242	4361	4543	4711	4952	5035	5253	5333	
Increase		..	536	107	244	151	167	70	68	256	342	119	182	168	241	83	218	80	3032

Inoculated against black quarter on 21—7—1922.

New feeding started on 5—8—1922.

TABLE III.

Giving weights in lbs. of "B" Number Calves on

Dates	13th July 1921	15th Oct. 1921	17th Jan. 1922	15th Apr. 1922	15th July 1922	29th July 1922	12th Oct. 1922	6th Jan. 1923	Average weight of each animal	Total increase
Bran and Cake series :—										
5 heifers	1099	1444	1595	1808	2106	..	2404	2696	540	..
Increase	..	345	151	213	298	..	298	292	..	1597
5 bulls	1195	1577	1730	1904	2214	..	2574	2838	570	..
Increase	..	382	153	174	310	..	360	264	..	1643
Total 10 animals	2294	3021	3325	3712	4320	4358	4978	5534	..	..
Increase	..	727	304	387	608	..	658	556	..	3240
Bran series :—										
5 heifers	1124	1382	1540	1701	2008	..	2353	2576	515	..
Increase	..	258	158	161	307	..	345	223	..	1452
5 bulls	1177	1455	1648	1875	2234	..	2599	2757	551	1580
Increase	..	278	193	227	359	..	365	158	..	..
Total 10 animals	2301	2837	3188	3576	4242	4361	4953	5333	..	..
Increase	..	536	351	388	666	..	710	381	..	3032

N.B.—Inoculated against black quarter on 21—7—1922.
Feeding started on 5—8—1922, with gradual increase of rations.

Taking the whole period of experiment into consideration, it will be seen from Table III that the weight of animals in the bran and cake series has increased from 2,294 lbs. to 5,534 lbs. or by 3,240 lbs. whereas that of those in the bran series from 2,301 lbs. to 5,333 lbs. or by 3,032 lbs. This means that the animals fed on bran and cake have put on 208 lbs. more weight than those fed on bran alone. This works out to an extra grain of nearly 7% in weight in favour of animals fed on bran and cake.

Looking at figures showing increase in weight during each quarter, it is seen that the maximum increase has taken place between July and October 1921 in the case of animals fed on bran and cake, and between July and October 1922, *i.e.*, exactly one year later, in case of animals fed on bran alone. In fact, during the first quarter of the experiment, the animals in the bran and cake series have put on 35% more in weight than those fed on bran alone. This difference in gain in favour of animals of the bran and cake series went on fluctuating during succeeding quarters till 29—7—1922 when the animals in both the series weighed almost the same—animals of the bran and cake series weighing 4,358 lbs. and those in the bran series weighing 4,361 lbs.

Judging from increase in weights during each quarter of the first year of experiments, it is seen that the animals have done well during two quarters—15th April to 15th October and only half as well from 15th October to 15th April.

A few days after the first year of experiment was over, on 29—7—1922 it was found that the animals in both the series had attained almost the same weights and it was decided to increase the concentrated feeds gradually and see the effect on the further development of the animals. Ever since the experiment was started on 13—7—1921, the animals had been receiving either 1½ lbs. of bran per head per day or the same amount of bran and 1 lb. of groundnut cake in addition. At the beginning of the second year, it was decided to increase the bran ration by 3 ozs. per head per day every fortnight till a maximum of 3 lbs. was reached and the cake ration by 2 ozs. till a maximum of 2 lbs. was reached. Feeding according to new rations was started on 5—8—1922 and the maximum was reached on 25—11—1922. The whole experiment closed on 6-1-1923.

During the period of increased rations the animals in the bran and cake series have increased from 4,358 lbs. to 5,534 lbs., *i.e.*, by 1,176 lbs. whereas those in the bran series have increased from 4,361 lbs. to 5,333 lbs., *i.e.*, by 972 lbs. In other words, the animals in the bran and cake series have put on 204 lbs. more weight than those in the bran series which works out to an extra increase of nearly 21%.

This increase in weight may not entirely be due to feeding alone, for, of the five heifers in each series all of them in the bran and cake series had been covered between 15—8—1922 and 19—11—1922 whereas only two animals of the bran series had been covered during the same period. One of the objects of continuing these experiments for more than one year was to ascertain if feeding with oil cake has any special influence on the maturity of the heifers and in hastening them in breeding. The fact that all the heifers in the bran and cake series were covered earlier than those in the bran series seems to indicate an earlier maturing tendency in the cake fed animals.

Till now the animals have been discussed in groups and it has been found that the maximum increase in weight takes place during the period July—October and that a mixed ration of bran and cake enables the animals to put on weights earlier than a pure bran ration. Comparing heifers and bulls by themselves, it is seen from figures in the tables that the sex of the animals has not had any appreciable influence on the development of the animals under different feeds.

It has already been stated in the last report that nothing really definite was known as to the age of these animals and their breeding. A new series of experiments on a similar plan was started with a further lot of calves, in which this information was available, on 17—12—1921 and closed on 15—7—1922. Tables IV and V give the details of age, breed of animals, their weights on different dates of the experiments and method of feeding. It is seen from the tables that each series has been subdivided into five groups. As far as possible corresponding groups in each series contain animals of the same age, breed and sex. Whenever it was not found possible to group them as above, a variation either in sex or breed of the animal has been introduced. This enables us to compare not only the two series and groups separately, but also animals of the same breed

and age but of opposite sexes, as well as animals of the same age and sex but of different breeds.

With regard to amount of concentrated feeds given to the animals, groups 1 to 3 in the bran series received 1½ lbs. bran per head per day and groups 4 and 5 containing younger animals, ¾ lb. of bran. Of those in the bran and cake series, groups 1 to 3 received 1½ lbs. cake and groups 4 and 5 received ¾ lb. cake in addition to bran. In addition, the heifer calves in both series were given a small quantity of milk during the early stages.

Comparing the two series with each other, it will be seen from the tables that animals in the bran series have put on 1,652 lbs. in weight which works out to an increase of 88%. During the same period of about seven months, the animals in the bran and cake series have put on 1,918 lbs. in weight and this works out to an increase of 107%. Thus the animals fed with cake in addition to bran were able to put on nearly 21% more weight than they would have done on a pure bran ration. Looking at the periodical increase in weight, it is seen from Tables VI and VII that except during the periods January–February and May–June, there has been a continuous improvement and the maximum increase in both the series has been reached in June–July.

Coming now to the various groups in each series, it is seen that animals in groups 4 and 5, *i.e.*, the youngest of the lot, do not show any appreciable difference in weight put on due to cake feeding. Animals in groups 1 to 3 were all more than 3 months old when the experiment was started. During a period of 7 months, those animals in the bran series have increased from 1,372 lbs. to 2,232 lbs. or by 860 lbs., whereas those in the cake series from 1,346 lbs. to 2,529 lbs. or by 1,183 lbs. This goes to show that cake feeding has enabled the animals to put on 323 lbs. or 37% more weight than under bran feeding alone. As already mentioned on page 69, the animals born in 1920 and bearing B numbers and more than 6 months old when the experiment was started have also shown almost the same increase in weight, 35%, due to cake feeding in addition to bran during the first three months of feeding.

Owing to certain economic reasons it was decided to sell away all the bull calves and so the heifers remaining were regrouped and

TABLE IV.

Giving details of "C" Number calves fed on bran and cake.

Group	Sex	Calf No.	Date of birth	Breed	Weight in lbs. on 17th Dec. 1921	17th Jan. 1922	15th Feb. 1922	16th Mar. 1922	15th Apr. 1922	17th May 1922	15th June 1922	15th July 1922	Total increase	%
1	Bull ..	9	18— 6—1921	Half-bred	135	155	165	192	228	245	273	301		
	Bull ..	11	15— 6—1921	do	129	147	165	186	215	239	253	270		
	Heifer ..	13	15— 6—1921	do	147	170	187	203	232	263	280	312		
	Heifer ..	14	25— 7—1921	do	136	153	147	150	170	190	196	226		
	Total ..	..	..	..	547	625	664	731	845	937	1002	1109		
	Increase ..	..	..	..	..	78	39	67	114	92	65	107	562	102
2	Bull ..	46	22— 4—1921	Sindhi	219	244	273	255	286	312	330	361		
	Heifer ..	45	24— 3—1921	do	169	186	198	210	224	242	255	280		
	Heifer ..	49	18— 8—1921	do	112	129	134	150	173	189	202	232		
	Total ..	..	..	..	500	559	605	615	683	743	787	873		
	Increase ..	..	..	..	..	59	46	15	68	60	44	86	373	75

3	Heifer ..	18	18— 6—1921	Half-bred	196	204	216	245	278	193	311	341		
	Bull ..	27	30— 7—1921	do	103	121	123	134	153	167	182	206		
	Total ..	..	..	..	299	325	339	379	431	460	493	547		
	Increase ..	..	..	..	..	26	14	40	52	29	33	54	248	83
4	Bull ..	21	9—11—1921	Half-bred	56	67	82	100	115	126	135	140		
	Bull ..	41	29—10—1921	Sindhi	53	64	67	81	88	98	97	112		
	Heifer ..	38	5—10—1921	do	80	95	109	134	154	174	179	203		
	Heifer ..	29	15—10—1921	do	63	74	93	114	127	146	146	159		
	Heifer ..	34	6—11—1921	do	70	89	104	124	140	170	179	209		
	Total ..	..	..	..	322	389	455	553	624	714	736	823		
	Increase ..	..	..	..	..	67	66	98	71	90	22	87	501	156
5	Bull ..	24	18—10—1921	Half-bred	72	95	106	145	166	201	229	263		
	Heifer ..	40	16—11—1921	Sindhi	48	56	67	76	80	87	84	91		
	Total ..	..	..	..	120	151	173	221	246	288	313	354		
	Increase ..	..	..	..	..	31	22	48	25	42	25	41	234	195
	Total for	16 calves	..	..	1788	2049	2236	2499	2829	3142	3331	3706		
	Increase	..	..	..	..	261	187	263	330	313	189	375	1918	107

TABLE V.

Giving details of "C" Number calves fed on bran alone.

Group	Sex	Calf No.	Date of birth	Breed	Weight in lbs. on 17th Dec. 1921	17th Jan. 1922	15th Feb. 1922	16th Mar. 1922	15th Apr. 1922	17th May 1922	15th June 1922	15th July 1922	Total increase	%
1	Bull ..	15	20— 6—1921	Half-bred	147	168	187	210	228	252	274	300		
	Bull ..	16	23— 6—1921	do	120	140	143	150	157	173	179	195		
	Heifer ..	17	15— 6—1921	do	149	170	175	189	204	224	244	265		
	Heifer ..	12	21— 7—1921	do	137	160	174	186	189	210	231	255		
	Total weight ..	..	..	..	553	638	679	735	778	859	928	1015	462	84
	Increase ..	..	..	..	..	85	41	56	43	81	69	87		
2	Heifer ..	47	10— 5—1921	Sindhi	181	193	201	206	226	249	253	279		
	Heifer ..	44	14— 5—1921	do	162	175	178	171	184	192	193	205		
	Heifer ..	8	30— 5—1921	Half-bred	167	186	197	215	218	239	249	274		
	Total weight ..	..	..	..	510	554	576	592	628	680	695	758	248	49
	Increase ..	..	..	..	..	44	22	16	36	52	15	63		

3	Bull ..	10	19— 6—1921	Half-bred	208	226	235	232	250	253	270	282		
	Heifer ..	19	26— 7—1921	do	111	121	124	134	143	156	175	187		
	Total weight ..	..	..	..	319	347	359	366	393	409	445	469		
	Increase ..	..	..	..	..	28	12	7	27	16	36	24	150	47
4	Heifer ..	28	1—10—1921	Sindhi	82	106	120	140	159	173	185	208		
	Heifer ..	37	15—10—1921	do	81	101	119	139	160	174	187	212		
	Bull ..	26	19—10—1921	Half-bred	50	63	78	89	93	98	100	112		
	Bull ..	39	24—10—1921	Sindhi	63	84	108	126	148	164	173	193		
	Bull ..	32	12—11—1921	do	68	88	96	106	117	126	130	147		
	Total weight ..	..	..	..	344	442	521	600	677	735	775	872		
	Increase ..	..	..	..	..	98	79	79	77	58	40	97	528	153
5	Bull	30	18—10—1921	Sindhi	64	79	102	125	149	165	174	203		
	Heifer ..	22	29—10—1921	Half-bred	69	91	108	133	148	160	172	194		
	Total weight ..	..	..	..	133	170	210	258	297	325	346	397		
	Increase ..	..	..	..	..	37	40	48	39	28	21	51	264	200
	Total for	16 calves	..	..	1859	2151	2345	2551	2773	3008	3189	3511		
	Increase		..	..	..	292	194	206	222	235	181	322	1652	88

TABLE VI.

Showing weights in lbs. of "C" Number calves—Bran and Cake series.

	17—12—21	17—1—22	15—2—22	16—3—22	15—4—22	17—5—22	15—6—22	15—7—22	Total increase	%
Group I										
4 animals ..	547	625	664	731	845	937	1002	1109		
Increase ..	..	78	39	67	114	92	65	107	562	102·0
Group II										
3 animals ..	500	559	605	615	683	743	787	873		
Increase ..	..	59	46	15	68	60	44	86	373	75·0
Group III										
2 animals ..	299	325	339	379	431	460	493	547		
Increase ..	..	26	14	40	52	29	33	54	248	83·0
Group IV										
5animals ..	322	389	455	553	621	714	736	823		
Increase ..	.	67	66	98	71	90	22	87	501	156·0
Group V										
2 animals ..	120	151	173	221	246	288	313	354		
Increase ..	..	31	22	48	25	42	25	41	234	195·0
Total of all Groups										
16 animals ..	1788	2049	2236	2499	2829	3142	3331	3706		
Increase ..	..	261	187	263	330	313	189	375	1918	107·0

TABLE VII.

Showing weights in lbs. of "C" Number calves—Bran series.

	17—12—21	17—1—22	15—2—22	16—3—22	15—4—22	17—5—22	15—6—22	15—7—22	Tota in-crease	%
Group I										
4 animals ..	553	638	679	735	778	859	928	1015	462	84
Increase ..	..	85	41	56	43	81	69	87		
Group II										
3 animals ..	510	554	576	592	628	680	695	758	248	49
Increase ..	..	44	22	16	36	52	15	63		
Group III										
2 animals ..	319	347	359	366	393	409	445	469	150	47
Increase ..	..	28	12	7	27	16	36	24		
Group IV										
5 animals ..	344	442	521	600	677	735	775	872	528	153
Increase ..	..	98	79	79	77	58	40	97		
Group V										
2 animals ..	133	170	210	258	297	325	346	397	264	200
Increase ..	..	37	40	48	39	28	21	51		
Total of all Groups										
16 animals ..	1859	2151	2345	2551	2773	3008	3189	3511	1652	88
Increase ..	..	292	194	206	222	235	181	322		

a new series of experiments—cake feeding *vs.* bran and cake feeding—was started on 5—8—1922. The details of the animals and their weights on different dates are given in Table VIII. The amount of concentrated rations was based on total protein content and each animal was given at the start, either 1½ lbs. bran together with 1 lb. cake per day or only 1½ lbs. cake, which is equivalent to ¾ lb. of total protein in each case. The bran ration in the bran and cake series was increased by 3 ozs. every fortnight and the cake ration in the other series by 1 oz. till a maximum ration of 3 lbs. bran and 1 lb. cake or 2 lbs. of cake was reached on 25—11—1922.

It is seen from the table that during the period of a little over 4 months ending with 9—12—1922, *i.e.*, a fortnight after the maximum of the rations was reached, the 11 animals fed on bran and cake have increased from 2,315 to 3,766 lbs., *i.e.*, by 1,415 lbs. or 63%, whereas the 11 animals fed on cake alone containing the same amount of protein have increased from 2,311 lbs. to 3,404 lbs., or by 1,093 lbs. or 47%. This shows that feeding with bran and cake enables the animals to put on nearly 35% more weight than it would have been possible for them with a pure cake ration.

The results of all these experiments show that a mixed ration of bran and cake is better than one either of pure bran or pure cake. Bran by itself is too bulky to be fed in quantities enough to supply the needed amount of protein and cake by itself seems to be too concentrated and does not provide the necessary bulk or suitable mechanical condition. Whether it is possible to replace wheat bran by a cheaper bulky concentrate with equally good results is to be tried next. The question of what proportion of bran to groundnut cake is best has also to be investigated.

The increase in weight of individual animals under the same system of feeding is not uniform. For instance, in the bran and cake series containing calves bearing C numbers, animal No. 40 has increased from 102 lbs. to 175 lbs., *i.e.*, by nearly 75% whereas, No. 47 has increased from 272 lbs. to 408 lbs., *i.e.*, only by 50%. Such variations are to be found in all the series of experiments conducted, and may be attributed to varying individual ability to digest and give returns from the food fed.

A similar series of experiments was started with younger animals

TABLE VIII.

Giving details of "C" Number calves (Heifers).

	Calf No.	Date of birth	Breed	Weight at start 5—8—22	Weight in lbs. on 19—8—22	16—9—22	12—10—22	12—11—22	9—12—22	Total Increase
Bran and Cake series	17	15— 6—21	Half-bred	259	293	321	360	405	451	
	47	10— 5—21	Sindhi	272	301	323	364	385	408	
	28	1—10—21	Sindhi	224	243	271	311	344	357	
	44	14— 5—21	Sindhi	212	244	268	310	336	347	
	14	25— 7—21	Half-bred	233	255	281	322	362	396	
	38	5—10—21	Sindhi	216	230	258	287	316	342	
	19	26— 7—21	Half-bred	194	220	256	294	325	353	
	40	16—11—21	Sindhi	102	121	145	157	161	175	
	36	25—11—21	Sindhi	223	249	263	287	305	317	
	64	7—10—21	Sindhi	197	222	245	219	305	325	
	62	2—11—21	Sindhi	183	206	216	248	274	295	
		Total weight	..	2315	2584	2857	3254	3518	3766	
		Increase	..	..	269	273	397	264	248	1451
Only Cake series	2	21— 7—21	Half-bred	247	278	309	364	380	404	
	8	30— 5—21	Half-bred	276	282	316	336	373	396	
	37	15—10—21	Sindhi	229	247	269	301	308	336	
	22	29—10—21	Half-bred	203	211	236	258	286	310	
	49	18— 8—21	Sindhi	235	247	260	293	300	319	
	34	6—11—21	Sindhi	227	233	254	268	290	297	
	29	15—10—21	Sindhi	174	185	195	226	230	255	
	35	28—11—21	Sindhi	130	148	158	176	188	199	
	43	8—12—21	Sindhi	221	255	275	292	312	330	
	54	30—12—21	Sindhi	206	218	233	256	280	292	
	57	30—11—21	Sindhi	163	176	197	228	249	266	
		Total weight	..	2311	2480	2702	2998	3196	3404	
		Increase	..	..	169	222	296	198	208	1093

TABLE IX.

Giving details of "D" Number calves.

	Calf No.	Date of birth	Breed	Weight at start. 5—8—22	Weight in lbs. on 19—8—22	16—9—22	12—10—22	12—11—22	9—12—22	6—1—23	3—2—23	Total increase
Bran and Cake series	3	8—1—22	Half-bred	160	195	217	240	268	290	312	342	
	7	20—1—22	Sindhi	168	202	232	255	266	282	298	318	
	17	8—3—22	Sindhi	91	111	128	150	170	186	207	221	
	20	9—3—22	Sindhi	108	134	155	177	195	213	238	268	
		Total	..	527	642	732	822	899	971	1055	1149	
		Increase	..	..	115	90	90	77	72	84	94	622
Only Cake series	2	8—1—22	Sindhi	161	192	213	233	246	255	267	278	
	11	7—2—22	Sindhi	159	184	206	237	243	257	274	289	
	14	3—3—22	Sindhi	93	110	123	146	160	173	190	203	
	13	2—3—22	Sindhi	114	142	170	186	190	200	217	246	
		Total	..	527	628	712	802	839	885	948	1016	
		Increase	..	..	101	84	90	37	46	63	68	489

and the details of those animals born in 1922 and bearing D numbers are given in Table IX. These were started with a concentrated feed ration of 12 ozs. bran and 8 ozs. cake or only 12 ozs. of cake, the rations being gradually increased till the bran and cake series reached a maximum of 3 lbs. bran and 1 lb. cake and the cake series a maximum of 2 lbs. cake. The feeding was started on 5—8—1922 and the maximum rations were reached on 20—1—1923.

During the period ending with 3—2—1923 the four animals in the bran and cake series rose from 527 lbs. to 1,149 lbs., or by 622 lbs. (118%). During the same period the four animals in the cake series increased from 527 lbs. to 1,106 lbs. or by 589 lbs. (111%). The difference between the two is not much, and the results are very similar to those obtained in groups 4 and 5 of calves bearing C numbers. The results of these experiments seem to indicate that in the early stages, the nature of the concentrated feed is not of such serious consequence as later. Whether this is due to the more complete digestive ability of the younger animal or to the fact that the ration fed was more than the animals' requirements at the time cannot be determined from these results. No check animals on no concentrated feed were kept as it was felt at the beginning of the experiment that some concentrated feed was necessary on account of the small amount of milk (2-3 lbs. daily) available for each animal. It is probable that, had more milk been available, the results obtained from the calves less than six months old would have been more nearly parallel to those obtained from the older calves.

What is meant by Good Silk ?

BY

N. Rama Rao, B.A., B.L.,

Superintendent of Sericulture in Mysore.

We hear people say "There is no silk like Mysore silk" or "This silk is better than that," and so on. But what do "good" and "better" mean ? Why good ? How better ? Good, because it is ours ? Good, because thin ? or white ? or what ? We might ask these questions out of mere idleness, or through a desire to learn—but we might usually wait long for an answer. We fare no bette

if we seek knowledge where silk is bought and sold. We hear that Kempanhalli silk is expensive, because it is very fine, that T. Narasipur silk is less valuable, because it is coarse ; that this silk has a good colour, and that silk has not ; that the water and climate of some places are excellent, and this sort of thing. We see people feeling the silk and looking at it and offering a price. If a few leading mutually acquainted merchants fix a price, that rules the market. But what are the grounds on which this price is fixed ? At present, not the perception of the inherent qualities of the silk—but mainly these considerations : (1) The willingness of the seller to sell, and (2) The probable price which may be got out of the weaver who buys ultimately. These limit the scope of the broker's skill—which is after all a trained faculty in bargaining. But does this take us any nearer fixing rational standards of quality ? We only know that prices vary—and that alone does not take us very far.

To arrive at a correct and intelligible standard, we must consider the natural qualities of silk, and the practice in other countries.

The distinctive qualities, super-eminence in which makes silk the undisputed queen of textile fibres, are strength, lustre, and ductility. So, any standard for silk must include these qualities. And as the utility of silk is in weaving, it must be in a form which facilitates the processes comprised in manufacture. This introduces some other factors, which are secured by good, and sacrificed by bad, reeling. Bad reeling, such as we see unfortunately common in our country, not only fails to subserve the convenience of the manufacturer, but actually injures the great natural strength and ductility of the Mysore silk. Our reelers have no means of testing these qualities, and therefore of realizing the damage they do ; their purchasers—the bulk of them at least, neither know, nor care, so long as they get a cheap silk. The test for silk is conducted with an instrument called a Serimeter, which gradually stretches a given length of silk till it breaks, and indicates the breaking strain and percentage of elongation. There are serimeters in the Mysore Filature, which are open to inspection and trial by our reelers who wish to see if their silks preserve their primary quality.

I have said that natural qualities might be damaged, and a silk inconvenient to handle in manufacture might be produced by Bad Reeling. But what is Good Reeling ? The rest of this paper

is an attempt to answer this question, with all possible brevity.

We shall assume (what hardly admits of doubt) that the object of the reeler is to preserve the natural excellence of the silk, and to give the weaver a "raw" which is convenient to use.

The weaver buys by weight, and sells by measure ; so he should know what measure he can get out of a given weight. This is only possible if the silk is uniform in diameter. If silk is of uneven thickness, there are other inconveniences also ; the thick parts might stick between the reeds, and the thin ones might break. Uneven silk produces a fabric of varying texture and thickness. The first quality is therefore *uniformity of size.*

The first process to which silk is usually subjected in all manufacture is winding. If this process is made difficult, there is not only waste of time and labour, but of material. In most weaving establishments, the time taken in winding and throwing, sets the limit on production. The causes which impede winding and make it difficult and expensive are gum, loose ends, defects of uncleanness, such as fluffiness, waste, bad knots, cork-screws, slugs, etc., and fine ends. The *freedom from breaks or loose* ends, and *from uncleanness* are the second and third indispensable qualities of good silk.

It is also essential that in reeling the fibre should not be weakened by over-boiling, or by neglect to see that the fibres cohere properly.

We shall now give a few practical hints about how these qualities can be secured by the reeler.

Uniformity.

The reeler must take the correct number of cocoons to obtain the given thickness of thread, and maintain the same number of cocoons throughout. Here, there are two things to be borne in mind—one, that the fibre is thicker in a good cocoon than in a bad one ; and therefore the cocoons used must be as far as possible of one quality ; the other, that the filament in the same cocoon is thinner at the ends than in the middle, and therefore the reeler should so manage that the fresh cocoons and the half-used ones supplement one another in the process of reeling.

The measure of thickness of silk is denier, which is the weight (in half-decigrams) of about 500 yards of the fibre tested. It has been ascertained that the size of a single filament of the Mysore

cocoon is 2 deniers. To get a thread of a given denier, the reeler should therefore take half as many cocoons as the number of the denier required.

The apparatus required for ascertaining the denier of silk can also be seen in the Mysore Filature.

To avoid loose ends, the reel should be stopped so soon as there is a break, and the ends should be neatly and securely knotted together. It is to be regretted that this is never done in our country, and that the reeler usually flings loose ends on to the reel with supreme unconcern. A single skein therefore consists of several hundreds of disconnected pieces of silk, which would drive to despair any manufacturer who employed power-driven swifts in winding. This is one of the chief reasons why our silk can never sell in countries where large up-to-date plants are employed for manufacture.

The uncleanness of silk is partly due to slovenliness in reeling, but chiefly to not having a proper *Croisure*. The water used for reeling must be clean, and of the right temperature. The filament in the cocoon is a fibre enclosed in a gum, and is disposed on the cocoon in figures of 8. This gum, being sparingly soluble in hot water, has to be cooked and softened before the cocoon can be reeled. If it is not sufficiently softened, the thread does not unwind ; if it is too soft, the thread slips off in loops before being stretched straight, and forms knots and lumps on the silk.

Owing to the natural filament being really composed of two strands coming out of the silk glands side by side, it is flat and not round ; and in the absence of a contrivance which brings about a combination under concentric pressure, the result of the union of a large number of these flat fibres would be a tape or a ribbon, and not a round, cylindrical thread. The croisure, which is the twisting of the thread in a spiral round itself, or the twisting of two threads upon one another, is such a contrivance. In our indigenous reeling, the threads go once round one another, and that is all. They should go at least 150 times round one another. A proper croisure not only gives a round thread, but prevents the grosser forms of uncleanness from passing on to the silk, and also squeezes out the excessive liquid gum which would otherwise make the silk sticky and difficult to handle.

Our silk would be better, and more highly prized, and therefore more valuable, if these obvious and easy improvements in reeling were adopted. Correct reeling is taught in the Central Institute of the Sericultural Department, at Mysore, by a Japanese Reeling Expert employed by Government. Persons desirous of improving their reeling technique under tuition may apply to the Superintendent of Sericulture in Mysore.

Manuring of the Areca Palm.

BY

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AND

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The local practice of manuring the areca palm in the malnad or Highlands of Mysore is described in detail on pp. 10 and 11 of "The Cultivation of the Areca Palm in Mysore" by Dr. Leslie C. Coleman and Mr. M. K. Venkata Rau. Experiments with artificial manures were started on the Marthur Farm in 1920. As a general manuring, the whole garden was given a dressing of farmyard manure at 20 lbs. per tree with the usual covering of green leaves and twigs. In only a few of the rows, the mulch of green leaves and twigs was replaced by one of crotalaria. The whole garden was divided into strips along the rows of trees and manured as follows :—

1. Check, *i.e.*, receiving no artificial manure.
2. Crotalaria, in which the usual soppu covering was replaced by this leguminous plant.
3. Nitrogen in the form of milled fish and ground-nut oil-cake.
4. Nitrogen as sulphate of ammonia.
5. Same as 3 and super.
6. Same as 4 and super.
7. Same as 5 and sulphate of potash.
8. Same as 6 and sulphate of potash.

Each of the variously treated strips has more than 2 rows of trees in it and there is a check strip after every two manured strips.

Each manurial treatment has been repeated on two different strips at least. The various plant foods were supplied at the following doses per tree.

Nitrogen at 0.25 lbs.= 5 lbs. fish or 3 lbs. cake or 3 lbs. fish and 1.25 lbs. cake or 1.25 lbs. Sulphate of Ammonia.

Phosphoric acid at 1 lb.=7 lbs. super.

Potash at 0.2 lbs.=0.5 lbs. Sulphate of Potash.

The manures were well mixed with the soil round each tree to a depth of about 6 inches. About a fortnight after the application of the artificials, cattle manure was applied and the whole thing covered over with soppu or crotalaria. Manure was applied for the first time in December 1920 and for the second time in October 1921 and subsequently in October 1922. As the whole garden had not been manured at all since 1917, to bring it into good condition as soon as possible, it was manured for three seasons continuously.

The condition of the garden improved perceptibly soon after it was manured for the first time in 1920. The yields of two seasons after manuring are as follows:—

Treatment	Yield of dried nuts in lbs. per acre of 400 trees			No. of trees harvested	
	1921	1922	Decrease%	1921	1922
Check series ...	620	455	27	630	658
Crotalaria ...	550	385	30	103	162
Cake ...	730	686	6	121	131
Sulphate of Ammonia ...	787	697	11	123	132
Cake and Super ...	650	697	+ 7	164	190
Sulphate & Super ...	727	728	...	153	161
Cake & Super & Potash...	948	822	13	144	166
Sulphate & Super & Potash	803	749	7	143	161

In 1922, the nuts were not allowed to get over-ripe as in 1921, but harvested when they were still tender enough and suitable for slicing. Hence the yield is slightly lower than what it would have been if the nuts had been harvested as in previous years.

The figures indicate that in both the years, the artificial manures have shown their effect on the crop. The substitution of crotalaria for the usual soppu covering has not shown any beneficial effect. The decrease in yield from one year to another has been greatest where no artificial manures were applied.

Information on the average yields from results of two years

and the increased yields over check series due to application of various manures is given in table below :—

Treatment	Dried nuts in lbs. per acre			Increased yield over check series per acre	
	1921	1922	Average	lbs.	%
Check series ...	620	455	538	...	+
Crotalaria ...	550	385	468	—70	—15
Cake ...	730	686	708	170	31
Sulphate of Ammonia ...	787	697	742	204	38
Cake and Super ...	650	697	674	136	25
Sulphate and Super ...	727	728	727	189	35
Cake, Super and Potash	948	822	885	347	64
Sulphate, Super & Potash	803	749	776	238	44

From figures in the above table, it is seen that the trees manured according to the local method have yielded 538 lbs. of dried nuts per acre which works out to 20 maunds nearly, *i.e.*, the average yield per acre for Shimoga District, as given in the table on page 2 of the bulletin referred to in the beginning of this article. Coming now to the action of individual manures, the yields indicate distinctly that both nitrogen and potash are needed. In the absence of a series manured only with nitrogen and potash, it is rather difficult to say with any degree of definiteness whether phosphates are wanted or not. With the figures on hand, one can only say that a combination of all the three kinds of manures has shown the best effect. Even of the combinations under trial, one of cake, super and sulphate of potash has given maximum yields in both the years increasing the yield on an average by 64 per cent.

The application of lime to a part of each series which could not be carried out till now for want of sufficiently cheap material has been done in November 1922, and the result of this will be available only later on.

After getting results for one more season at least, the question of the most economic doses of these artificial manures will be taken up either in the Marthur garden itself or in co-operation with some of our members.

It is also quite necessary to make sure of the necessity or otherwise of superphosphate, for if that manure is not wanted, there will be a considerable saving in the cost of manuring.

Green Manuring Experiments on the Marthur Farm.

BY

D. G. Ramachandra Rao,

Assistant Director of Agriculture, Shimoga.

In the Malnad or the Highlands of Mysore where large areas of rain-fed paddy are grown the procuring of an adequate supply of manure is a really difficult problem. The pelting rain washes and denudes the soil of its fine particles and leaves the surface soil poorer and poorer day by day. The supply of organic matter to the soil is therefore a matter of very great importance. The green leaf of the vast forests of the malnad cannot be utilized owing to scarcity of labour. Growing a green manure crop on the paddy land itself and turning it under, is probably the best and the easiest way of securing a good supply of organic manure.

In the Malnad, after the harvest of paddy in December, the soil is still moist enough for the sowing of a green manure crop. This is especially so in the case of low lying lands and those situated under tanks. Sowing of a green manure crop may be done here from February to April according as moisture conditions permit.

With a view to find out a suitable green manure crop, an experiment was started on the Marthur Farm during the last season. The crops selected for trial were sann hemp (*Crotolaria juncea*) and cowpea (*Vigna catiang*), the two crops usually grown for the purpose. With this experiment was combined another—that of stimulating the growth of crop by applying superphosphate at 240 lbs. per acre. The following table gives the quantity of green matter obtained and turned under in each case :—

	Green stuff obtained per acre in lbs.
Sann hemp	2,920
Sann hemp with superphosphate ..	15,680
Cowpea	1,640
Cowpea with superphosphate ..	3,560

As can be seen from the table, sann hemp has given about 78 per cent more green stuff than cowpea. With superphosphate on cowpea 113 per cent more green matter was obtained than without it. But the effect of super on sann hemp was remarkable. While sann hemp by itself gave 2,920 lbs. of green stuff per acre, stimulated

by superphosphate it gave 15.680 lbs. of green matter or an increase of about 437 per cent.

The following table gives the results of the subsequent crop of paddy from the plots green manured as above.

Plots.	Yield per acre of the subsequent crop of paddy in lbs.	
	grain	straw
Check	1,360	1,840
Sann hemp	1,840	2,560
Sann hemp stimulated by super	2,520	3,400
Cowpea	2,120	2,520
Cowpea stimulated by super	2,080	2,680

Comparing the plots that had green manure with those that had no manure the sann hemp plots have given an increase of 35 per cent of grain and 39 per cent of straw over the check. Cowpea has given an increase of 56 per cent of grain and about the same increase of straw as sann hemp. But the results from the green manure plots which had superphosphate are remarkable. The sann hemp plots which had received superphosphate also, have yielded about 85 per cent more grain and straw than the plots without it. The cowpea plots that had received superphosphate for that crop gave no increase of grain and only a little of straw over those without it. The cowpea plots manured with superphosphate bore pods one month earlier than the others without it and the crop was profusely laden with pods when it was ploughed in ; this perhaps accounts for the poor result shown by the subsequent crop of paddy. The green manure, especially the large quantity of sann hemp, incorporated with the soil may show its residual effect this year.

The experiment is being continued this year also. Encouraged by these results the whole of the bulk area of paddy on the farm has been sown this time with sann hemp which seems likely to develop into a good crop.

The greatest hindrance to the growing of a green manure crop on paddy land in the malnad is the damage done by stray cattle. After the harvest of paddy the cattle are let loose and unless all people combine and agree to watch their animals the raising of a green manure crop is absolutely impossible. The results of the experiment stated above justify such a combination.

The Cocoanut Beetle.*

BY

H. Srinivasa Rao,

Retired Deputy Conservator of Forests. Hongenahally.

Last year I undertook to continue further my investigations about the cocoanut beetle. Three experiments were suggested to me : (1) Tarring the parts likely to be attacked. (2) Using marothi cake with a mixture of nux vomica seeds. (3) Filling the holes bored by the beetles with a mixture of sand and common salt.

Of these the first was not found quite practicable, for the beetles attack not only the base of the growing shoot but also bore through the broader portion of the petiole and the midrib of the older leaves and they break and hang down when the monsoon winds blow. The palm with the leaves destroyed looks like a tree pollarded. In a large plantation it was found impossible to tar each leaf of each tree and keep repeating it every now and then as fresh leaves appear. For this reason the tarring process would require an enormous quantity of this stuff and labour also, which is not possible to procure at a reasonable cost.

For the same reason the trial of marothi cake was also postponed. It will be taken up early next monsoon when the daily attacks will be the largest.

The last suggestion of filling the holes with sand and salt was taken up for trial about March, 1922 and continued for about 4 months. At first it was noticed that the beetles avoided the old holes filled with sand and salt, but after a few weeks it was clearly seen that they entered them, scooping out the sand and salt.

It is common experience that a single beetle cannot kill a plant 3 to 4 years old in a day. But there is danger if it is left undetected and unextracted for days together so as to allow it to destroy the growing tissue. The younger the plant the sooner is the growing tissue reached. There is also danger if a fresh beetle enters an already bored hole, as it could work down from where the previous beetle had left it and complete the damage. In this case detection of the beetle is also difficult as when the beetle entering an old hole throws

*For the first report by the same author *vide* Vol. II, No. 4 of this Journal.

out no fresh tow-like stuff by which the point of attack is easily detected. It is therefore very important to keep off new beetles from old holes and as sand and salt stuffing was not a satisfactory preventive, I had to think deeply over the matter, and at last it occurred to me that the presence of dead beetles in the old holes might deter live ones from entering them as it is animal nature generally to avoid places where dead ones of their own species are found as observed among rats, house flies, crows, etc. I accordingly instructed my men to fill the holes with sand and salt and insert a dead beetle picked the previous day into the hole at its entrance so as to make it visible from outside. My men have been doing it for the last 3 or 4 months and till now no case of a new beetle attacking through the same hole has been found. Rare instances have been noticed of fresh beetles entering an old hole boring from some other side but never through the entrance of the old boring. When they attack from a fresh point they are easily detected and picked. I think this is a step in advance towards combating the pest and interested gentlemen are requested to give this method a trial in their own plantations.

NOTES AND COMMENTS.

Steam Plant for making Jaggery.

Our members and readers might be interested to know that a steam plant for making jaggery has been set up on Mr. Krishna Iyengar's estate at Oragahally by the Department of Industries and Commerce. The equipment consists of 3 rectangular eliminators with a steam coil in each for heating and clarifying the juice, 2 round evaporators with 2 steam coils in each for concentrating the clarified juice and a Wetzel pan with a rotating steam coil for boiling down the concentrated syrup from the evaporators into jaggery. The steam necessary for the operations is supplied at about 60 lbs. pressure by a boiler supplied for the purpose. The fuel used for generating steam is partly firewood and partly begasse. It is a pity that the erection of the plant, excluding the Wetzel pan, could not be finished before the tail end of the milling season. Consequently, the eliminators and the evaporators were worked only during the last 2 days and the concentrated syrup was boiled down into jaggery in ordinary round pans over an open fire.

The three-roller mill owned and worked by Mr. Krishnaiengar for over 15 years is driven by an oil-engine and is just enough to supply the eliminators with the necessary amount of juice. While one of the eliminators is being filled with juice, the second one is used for heating and clarifying the limed juice contained in it, and clarified juice from the third one is being run out into one of the evaporators. After steam is turned on, the limed juice remained in the eliminators for about one hour. About 30 minutes after turning on the steam, the "blanket" forms on the surface of the juice and is at once skimmed off into a gutter attached to it. Further skimming goes on during the next 15 or 20 minutes after which the juice is allowed to settle for about 10 or 15 minutes and then run off into one of the evaporators.

Each evaporator takes up juice from two of the eliminators. Steam is turned on in one of the evaporators soon after clarified juice from one of the eliminators is run into it. In about half an

hour's time, juice from another eliminator is run into the same evaporator. The clarified juice from two eliminators concentrates in one evaporator for about 2 hours, after which time it is ready to be emptied into the Wetzel or the local round pan.

Since the Wetzel was not ready for operation, syrup from one of the evaporators was run into 4 round pans and boiled down into a consistency required for jaggery in about 45 minutes, cooled and put into moulds as usual—about 15 to 16 maunds of good jaggery being produced each time according to the quality of juice boiled.

[B. N. I.]

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Some Interesting Results with the Trash Trap against the Sugarcane Borer.

This new line of attack against the Sugarcane Borer has again been tested with even better results than last year. On the Babboor Farm the damage of the borer has been reduced to 1.50 and 2 per cent over 20 acres of cane. The method is being tried in several other localities but this short note is intended to draw attention to the possibilities of this method of control against other insects. It was noted last year that, besides the moth borers several other species of moths are also attracted to the heap. The number of these is very large and many of them have not been identified. Along with these this year, there were found large numbers of mole crickets. In one trap alone, over sixty in all stages of growth were counted. Now, mole crickets are also responsible for dead hearts though in a smaller degree. They bite holes into the cane from outside near the ground level and without getting in eat off the soft tender portions. The result appears as a dead heart. In other localities they have not been found. Besides the cricket, the ground beetles (*Opatrum* and *Gonocephalum spp.*) were also found crowded together underneath these heaps. This points to an easy method of collecting these in localities where it has been found to attack ragi seedlings. A third interesting species was a Carabid beetle which was probably after the moth borers in the heart. On the Nagenahalli Farm, the small Cockroach was found in abundance and it was difficult to distinguish the moths amidst the flight of these as the heaps were disturbed.

It appears possible from these experiences that other moth pests

can be controlled by similar methods and it is proposed to carry out experiments against the paddy stem borer and other pests of a similar character against which no satisfactory remedy exists at present.

[K. K. K.]

* * * * * * * *

Reeling Competition in the Mysore Filature.

With a view to take the best Reeler in the Filature at Mysore on to the permanent Staff of the Sericultural Department, an Operative's post was thrown open for competition. The test was of 10 days' duration; the daily maximum was 500 marks (making 5,000 for the whole) apportioned as follows :—

Weight of silk	300 Marks.
Rendita	100 „
Size	100 „

There were 24 candidates, and the competition was very keen as will appear from the marks list of the best five :—

1. N. Puttamma	3754
2. Mukunda Rao	3602
3. D. Nanjappa	3469
4. S. Nanjappa	3394
5. Venkatamma	3020

N. Puttamma, who has won the post is really a good Reeler, and others are nearly as good.

Some of the results of the trial may be of interest, as furnishing reliable data in regard to the Filature Industry.

Working 6½ hours a day, and Reeling 13/15 deniers, the average daily output of silk was as below :—

N. Puttamma	372 grams.
Mukunda Rao	337 „
D. Nanjappa	344 „
S. Nanjappa	331 „
Venkatamma	305 „

It took an average of 15.3 grams of cocoons to reel 1 gram of silk.

These results are of great value for the future of the Filature Industry in Mysore, and show that with suitable training our reelers

compare very favourably with similar workers in any other country making due allowance of course for difference in the nature of our raw material.

It is probably known that Mysore silk takes a very high place in the world's silks in Lustre, Elasticity, and Tensile Strength.

[N. R. R.]

* * * * * * * *

The Poorest Holding in the Village.

Which is the poorest holding in the village ? Which is the holding that yields the smallest income, yet on the cultivation of which the ryot and his family depend wholly or almost wholly for their livelihood ?

We wonder how many among the Members of the Union have asked themselves this question or if it has occurred to them how many have tried to find an answer ? Yet there is no question more important in agricultural economics especially in the economics of a country so largely dependent on agriculture as India.

To those unacquainted with agricultural economics the information sought in the question may appear trivial. But a little reflection will show how it is vital in every enquiry worth the name in regard to the condition of the ryot population. We have long reached in most parts of India, a condition of very great, we shall not say extreme, pressure of population on land. With the decay of industries and the growth of population, people have had to fall back on land as the sole resource left to them. As the pressure increases, they are driven to take up land of less and less fertility. The quality and extent of yield of the poorest holding is therefore a measure of the growing pressure on land between the income from the poorest holding and the wage level in the tract. For, it is obvious that holdings which yield appreciably less than the wages of unskilled labour will not be taken up for cultivation. There are factors which tend to interfere with this relation that undoubtedly exist. In the first place, labour is not mobile or educated enough to take advantage of attractive wages in distant places. Secondly, the conservatism of the cultivating classes and the predisposition to inherited pursuits are such that employments are less easily deserted for those of a more remunerative character. Against this, however, has to be set the

important fact that in India the capital required for farming on a small scale is very small and when opportunity exists people would try to start farming even if the return be less than what a day labourer would get. For there is security as well as status attached to farming. These factors vary in their relative importance so much that it is difficult to decide at what point in the wage level, farming would be left off ; but ordinarily it is safe to assume that the wage level of a tract will be a little higher than the earning from the poorest holding in that tract.

A third interesting result of the enquiry would be the light thrown on the standard of living. It is acknowledged on all hands that there has been a steady deterioration in regard to it among the masses of the population. The income from the poorest holding gives exact information as to how far it has proceeded. For, it is obvious that the owner has to adjust his expenditure to the income he derives from his holding.

The increase in rent is another important consequence of bringing under the plough of poorer land. There are many factors involved in the rise of rents, all over the world, and in India there is the further factor of a heavy land tax increased every 30 years. It will take me too far to go into these but one important consequence of very poor land being taken up for cultivation is that rents rise. For, the man who is driven to earn a precarious living out of very poor land would sooner lease a land for that same return, the difference between that and the total produce being willingly made over to the landlord. For, the richer the land the greater the security of return from labour spent on it, and returns to the cultivator from rich land and poor land remaining the same, the deciding factor is security. The man who is therefore anxious to start farming will not fall back on poorer land before he has made certain that he cannot get better land on lease. It is therefore obvious that under conditions where poor land is being increasingly taken up for cultivation, there has been keener competition for better land, and rents increase when competition is keen. In these cases at least, the charge of rapacity against the landlord cannot be sustained. For, if he stands to gain by the competition, the competition itself is not of his creation.

To illustrate these factors let us suppose the holding of a village

divided into several grades A, B, C, D, & E. of which those in the E division remained for long uncultivated. Let us suppose also that the income from holding in A, B, C & D divisions are respectively Rs. 200, 175, 150 and 125 an acre. The land under D will just repay expenses and labour of cultivation and no rent. The rent in the other holdings in A, B & C will be Rs. 75, 50 & 25 respectively. If now as a consequence of increased pressure on land resulting from want of more remunerative occupation or from any other cause the land in the E division is also taken up as holdings, each of this will yield only Rs. 100. As a direct result of this rents have gone up in the first three divisions which will tend to be Rs. 100, 75 and 50. The holdings under the D division which previously earned no rent would now yield about Rs. 25 to the owner. This large increase in the rent has been brought about by the fact that there was not enough good land for all that wanted to lease it and the competition set up the rent, those that failed to get any being driven to the poorer land. If we now consider this last class of farmers in the E division it is obvious that their position is much worse than when the lowest class of holdings was in the D division. For, whereas Rs. 150 was the income from the holdings in the last division the holdings in the E division brings in only Rs. 100. With this lesser amount the poorest family has to live in the village and to that extent their standard of living has deteriorated. The wages for day labour will have also decreased in proportion but as before will be more than the income from the poorest division holding. One other interesting fact appears from the analysis above. It is often thought that the large amount of land left uncultivated by landlords for which nevertheless they pay rent is due to want of sufficient and timely labour. While there is no doubt this is an important cause it is now seen that there is involved a speculative element and the landlord prefers to pay tax without cultivating lands, because he expects that in the course of a few years they will begin to yield rent and he is not disappointed, because the pressure on land is steadily on the increase all over and lands in the D division which might not have yielded any rent for years might begin to yield rent as soon as land in E division is taken up.

The interest and importance of the enquiry is now obvious. We see now that the formation of a small holding out of land long considered to be useless for cultivation is by no means to be dismissed

as an instance of the stupidity of the humble individual who has ventured in that precarious enterprise but is an important incident that has come up to our view which gives us valuable information as to the extent and direction of the vast forces that are at work beneath the surface. It would help forward to a real understanding of the situation of our ryot population and therefore to more and more correct methods of tackling the many problems connected with it if we could bring together reliable data regarding the poorest holdings in every village in Mysore, and no one is in a better position to undertake the enquiry than the members of the Agricultural and Experimental Union resident in the village. We would appeal to them to make their very best efforts in the direction. Agricultural improvement in India is, as we pointed out at the very first meeting of the Union, as much a matter of economics as science and we cannot neglect the one or the other without impairing the efficiency of the whole scheme of agricultural improvement. To those therefore who would undertake the enquiry we append a questionnaire. We need scarcely say that absolute accuracy is required in regard to the information and that facts have to be gathered together from the widest possible area and under every variety of conditions before right conclusions can be drawn.

THE QUESTIONS ARE :—

1. The name of the village, population, location, area.

2. The size of the poorest holding.

3. The character of the land ; the division in which it is placed in the Revenue Survey ; the tax and rent paid ; extent of wet lands.

4. Crop raised. The total yield of each crop. Their estimated value.

5. The number in the family ; the number who work in the field—who are from age or incapacity unable to work.

6. The nature of the subsidiary occupation—the estimated earnings from it.

7. The amount paid for labour, if any.

8. The wages for unskilled labour in the locality.

9. When was the holding first taken up for cultivation ; brief history of it since first cultivation, transfer by sale, division on inheritance, debts incurred, etc. [K. K. K.]

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SELECTIONS.

I

Improper Care of Farm Implements.

On the principle that "one touch of nature makes the whole world kin," farmers everywhere must be the closest band of brothers that ever existed, for there is one thing that is common to them in every land, *viz.*, the indifference they display towards their mechanical equipment. In this country it is no uncommon sight, winter or summer, to see implements and machines left out in the fields, apparently forgotten, for days on end, and when the rain comes along harm is invariably done. Foreign travel reveals that British farmers are not alone in this neglect, for in almost every agricultural centre on the Continent the same indifference is most glaringly revealed by a tour of the farmlands. In the United States, too, the inadequate care, and housing of farm-machinery is estimated to cost "millions of dollars" annually, and so it would seem that, in this thing if in no other, farmers are equal the world over. It is very strange why it should be the exception rather than the rule for a man to take really good and reasonable care of his own property, or to cause those whom he employs to do so, for it is undoubtedly true that the farmer himself is the loser in the long run. It may be that he regards implements as either unworthy of protection or not requiring any, but in any case he is wrong. Well-kept implements, free from rust and with no dirt adhering to the working parts, are far more efficient than others, and are also better investments in that they last longer. But the farmer thinks a harrow takes no harm in any sort of weather, a hoe is proof against everything, a plough too strong and sturdy and ever clean-scouring to need any sort of protection, a drill may have its "days out" without suffering hurt, and even the scanty covering of a hay-maker, a mower, a binder, or a tractor suffices for all practicable purposes. Perhaps there is some slight excuse for leaving out "to weather" those implements whose transport along country roads is anything but easy; but, on the whole, the farmer has long been weighed in the balance in this matter and found wanting.— *The Implement and Machinery Review, Vol.* 48, *No.* 575.

II

Conditions of Entomological Work in India.

The development of Economic Entomology as a branch of Scientific Agriculture is so largely due to the United States, that in countries where its importance was recognized only later there has been a pronounced tendency to adopt methods and results obtained in the States without reference to their suitability to local conditions. India is no exception to the rule. The importance of the investigation of crop pests was recognized only late in the eighties of the last century, but the duty was left in the hands of men who were engaged in Museum work and who were, therefore, not able to investigate the pests reported to them. It was inevitable, therefore, that recommendations were made based on results obtained in the States, and that several of them proved useless. It was not till 1901 when the Department of Agriculture was reorganized and an Agricultural Research Institute established in Pusa, that a full-time officer for the study of pests was appointed. Since then the work has rapidly developed. Two of the Provinces have entomologists of their own, and there is in all the Provinces a staff of subordinate officers. In Mysore, one of the Native States, an entomologist was appointed as early as 1908. The Entomological staff in India is still unequal to the immense task before it, but in the next few years a more rapid increase in the staff is likely to take place.

Entomological work in India is largely determined by the local conditions, and these are different from those of most other countries. India is a land of peasant proprietors. The average size of a holding is only four acres against sixty or eighty in the United States, and the yield from an acre represents on an average only what an American farmer would willingly spend in spraying alone. Any costly remedies such as those employed in the States are, therefore, entirely out of question except in regard to crops like coffee and tea, in which the yield per acre is sufficiently high. The consequence is that the entomologist has to devise methods which are within the very small means of the Indian farmer, and spraying, as a general proposition, cannot be considered at all. Such remedies are being devised, with the increasing recognition on the part of Indian entomologists of the profound difference in Indian conditions from those of most Western Countries. Provided the remedy satisfies the requirements indicated above, the Indian farmer can, as a rule, be easily persuaded to adopt them. Indeed, he himself has not been slow to devise certain ingenious remedies. The insecticidal property of mercury

was long known to him, and it was not before it was proved by me* that any entomologist thought of the value of the metal in that connection. So, too, in regard to the storage of pulses he has hit upon devices which stood the test of scientific investigation. The simple method of putting a layer of sand on top of stored pulses, which I have suggested as an effective means of safeguarding them from the Bruchids, was derived from a study of the local methods of storing them.

Fumigation, as a method, is inapplicable to conditions in India, where each farmer stores his own pulses for the year, and where villages are so far apart and have such crude facilities of transport that distribution of the chemical could not be done on any large scale. Nor could the farmer be entrusted with so dangerous a chemical. The different method required of storing pulses in India is an illustration of the lines the entomologist has to proceed in India. The remedies that are now being devised take into account this fundamental fact. In my own State several remedies have been devised which are of a very simple character. The treatment of *Nymphula defunctalis*, an amphibious caterpillar pest of rice, with kerosening the water in the fields, was proved simple and popular. Another serious caterpillar pest which devastates many dry crops of the State is being controlled by the handpicking of the moths, which are conspicuous objects in the bare field, and easily caught and killed by the children of the village. More examples need not be given to show how very different are the lines in which entomological work has to be carried on in India. If in all work relating to the control of pests in India, regard be had to the attenuated and fragmentary character of the holdings of the farmer and his very small means, often hardly adequate to bare livelihood, there can be no doubt that the diffusion of knowledge of Economic Entomology will be as quick and widespread as in the States.—K. K. K. in *Pro. Haw. Ent. Soc.*, V, *No.* 1.

III

Tilth and its Importance in Soil Cultivation.

The value of the soil cannot be always judged from its chemical composition only; its physical properties are no less important. Indeed upto a point the fertility of a soil is as much dependent upon its physical properties as regards aeration, moisture and temperature as upon its chemical composition.

* It has recently come to our notice that in a "Treatise on the Culture of the Pineapple," by William Speechly, published in London in 1821, on pages 321-329, is an account of a method of using quicksilver for the destruction of scale insects on pineapple. [*Ed., Pro. Haw. Ent. Soc.*]

The bearing of the physical properties upon the productive capacity of a soil cannot be too much emphasized, as it has been known that a soil may contain all the elements of plant nutrition and yet not yield a good crop. Indeed, in order to get the best results from the application of artificial manures, it is essential that the soil must have a good *tilth*, by which is meant that it has been wisely tilled or cultivated. Good tillage involves an intelligent choice of the time at which to begin cultivation as well as proper treatment with necessary implements. For instance, if the soil is too wet or too dry, no amount of subsequent cultivation will produce a good seed bed which has much to do with the success or failure of a crop. A good tilth not only favours the extension of delicate roots of the seedling plants but it also ensures the proper supply of air and moisture and influences the character and intensity of the chemical action by which the plant food is manufactured. Production of good tilth is, therefore, an essential preliminary for successful crop production and especially is this so in clay soil.

Generally speaking, the soil is made up of particles of various sizes and nature, packed in diverse ways with colloid matter or clay, irregularly distributed throughout it. In order to obtain a good tilth it is necessary that the fine constituents of the soil—fine silt and clay—should not behave as such but should form part of larger compound particles loosely held together, which do not offer too great a resistance to the free passage of water and air, or to the penetration of the roots of plants.

The formation of good tilth is largely the result of suitable cultivation. By this means, the soil is placed in such a condition that the forces of nature, temperature, drought, rain, frost, etc. exert their greatest influence whereby the ultimate particles of a soil are aggregated by slow degrees into easily fragible larger compound particles, or in other words, flocculated. This conversion does not take place when the soil is too dry or too wet. The optimum condition varies with different soils but approximates to that of half saturation with water. The difference in temperature between the night and the day time, alternate drying and wetting in drought and rains, frost and thaw in cold climates, all these agents induce alternate expansion and contraction. They thus produce unequal strains in the different parts of the soil accompanied by an increase of volume in its upper layers. Thus the larger particles are formed with correspondingly large intervals of separation which, assisting aeration, help in making available increased supplies of plant food.

The presence of colloid substances such as clay and humus, etc., has a great bearing on the promotion of tilth. Besides their behaviour

as regards the remarkable expansion and contraction as is observed in the shrinking and cracking of clay and peaty soil in the dry seasons and their swelling in the rains, they act as cement holding together the finest constituents of the soil and thus help in increasing the stability of the particles. This action of clay is dependent on the phenomenon of coagulation. It is to be generally observed that the conditions which favour the coagulation of clay are also those which determine the formation of tilth in clay soil, *i.e.*, witness the improvement of clay soil with dressings of lime which latter is known to be an effective re-agent for flocculation of clay.

Application of green manures, cowdung and farmyard manure has also a great influence in improving the tilth of soil. Humus produced from the decomposition of the above, helps in the cohesion of particles in the sandy soils and thus improves its capacity for retaining water while in clay soil it lessens the stickiness of clay by opening up the particles by the incorporation of decayed vegetable tissues and as these latter are porous the clay becomes more pervious to water.

Of the common fertilizers used in farms lime has already been noted as a good producer of tilth, while sodium nitrate in large quantities, on the other hand, has a harmful effect since repeated applications of this fertilizer make the soil sticky. The nitrate soon loses its nitric acid in the soil and ultimately exerts an alkaline influence, which is responsible for the deflocculation of the particles. This is the reason therefore that whenever sodium nitrate is to be applied it is recommended that it should be mixed either with ammonium sulphate or superphosphate These latter are acidic in reaction and they neutralize the alkaline effect of sodium nitrate.—*The Bengal Agricultural Journal.*

IV

Artificial Silk.—An Italian Review.

The twenty-fifth anniversary of the appearance of artificial silk fabric on the market has just been celebrated, and a statement of the rise and progress of the industry is therefore of interest.

The idea of producing a thread which should approximate to the thread of the silkworm goes back as far as the time of Reaumur, who devoted much time and attention to this possibility. But it was only in 1885 that the Swiss Audemars revived the question and succeeded in producing a nitro-cellulose that could be made into a thread, composed of leaves of mulberry with the addition of gum. Audemars took out a patent for his discovery.

The real creator of the thread which proudly bears the name of artificial silk was, however, the French scientist, Count Hilaire de Chardonnet. In 1885, after a persevering study of more than ten years, de Chardonnet succeeded in solving technically the problem of producing this thread from nitro-cellulose, thus giving substance to the chimera on which he had spent a large portion of his life. He obtained a first patent for the manufacture of silk, which he called alcohol silk. This, however, proved too inflammable, and was improved in the course of time by submitting it to a process of denitration. Only ten years later Chardonnet gave a practical and industrial form to his invention by putting on to the market a thread suitable for fabrics.

Realizing the enormous future opened up by this new industry, chemists of many countries devoted themselves to the study of improving artificial silk, with the result that there are over 2,000 patents in the field. The thread progress passed successively from the alcohol silk of de Chardonnet to that of the "cuprammoniacate" silk of the Frenchman Depaissis (1890) and of the Germans Dr. Pauly, Bronnert, and Fremory and finally reached the production of viscose silk. This last form not only has the requisite and best characteristics for all textile uses but also possesses the enormous advantage of a low cost of production.

Viscose silk (sulpho-carbonate of cellulose), discovered and patented in England by Cros, Bevan, and Beadle in 1892, is the one which to-day controls the world market, with some thirty-eight factories widely distributed. Thanks to the persevering studies of the Prince Henkel von Donnersmark in his establishment at Sidowsaue, and to the work of the combined factories of Kelsterbach of the Main, the history of this silk has been continuously progressive.

There is also on the market an artificial silk of an imperfect nature called acetate silk (cellulose ether) produced by Mork, which in view of its special qualities of non-permeability and strength is certainly assured of a large market when the technical difficulties hampering its production are overcome.

In order to obtain a just idea of the great development in the artificial silk industry a few figures will suffice. In the year 1902 the world's production amounted to, roughly, 2,000,000 kilogrammes per year. By 1921 this had increased to 20,000,000 kilos. This last figure represents nearly 50 per cent of the world's production of natural silk, which, according to official statistics, amounted in 1921 to 42,000,000 kilos.

Mistaken ideas exist in the silk world, particularly in France, that the

ascending tendency in the artificial silk industry is taking place at the cost of the consumption of natural silk. In reality, however, the new fibre has not only created a market for itself without influencing the others but has also provided the textile market with a considerable number of new articles. This statement is actually supported by figures, for by taking the year 1914 and to-day it is seen that, in spite of the striking increase in the world production of artificial silk, natural silk has made an enormous advance the output having risen from 29,220,000 kilos in 1914 to 41,960,000 kilos in 1921.

It can be understood that such a flourishing industry has given rise to the most lively rivalry and cupidity in the technical field of industrial invention. As improvements or new inventions were brought out they were appropriated by the more important companies, with the result that a consortium was gradually formed which has since grown more and more powerful. The members of such a consortium are tied down by technical and economic bonds, and the general effect is to suffocate all outside initiative. For this reason the concerns that have succeeded in living their own life and in making headway against the monopoly are very few. In Italy, for example, of six factories existing, and two now being constructed, the only remaining free one is the latest; this factory, situated in the Valle d'Aosta, is of most modern construction and of enormous productivity.

From the fact that it gives regular work directly and indirectly to more than six million hands, the Italian artificial silk industry becomes an absolute co-efficient in the national economy of the country.— *British Indian Crafts, Vol. I, No.* 12.

V

Agricultural Instruction in the Elementary Schools.

The reasons assigned for placing Agriculture on the Elementary School curriculum are so many and so varied and the results obtained in actual practice so diverse that a restatement of the whole case should be of interest at the present moment. Although much has been done it is yet too soon to reach a final conclusion as to the true value of elementary agricultural instruction nor is it fair to condemn it because of failure in presentation. After many years of experiment the teaching of Arithmetic in our schools is far from satisfactory, while grammar and history still prove stumbling blocks in the path of many otherwise successful teachers. In these subjects the range of material as well as the limits of the field are quite clearly defined. On the other hand, Agriculture is a growing science increasing since it draws on the whole field

of experimental science. In addition it is a practice with frequent change of method and application. It is not strange therefore that the most extreme opinions as to its success and value as a public school subject should be held.

To discuss the problem adequately, the following points must be carefully considered. What is the aim or purpose of elementary agricultural instruction ? Is it vocational or pre-vocational in the accepted sense of those terms ? Or is it simply educational ? Then what range of work should be attempted and what methods employed in the presentation ? Finally, what success has attended the effort and is it worth the time and energy expended ?

In Saskatchewan, Agriculture has been a subject of study in the public school for many years but for the past seven years special efforts have been made to make the work more efficient. This article does not claim to deal with the general problem but rather to discuss what has been attempted in this province and to draw a few conclusions therefrom.

In the first place, the aim or purpose of the course is the development of a more efficient citizenship. It is not taught to keep boys and girls on the farm but is believed that the education of our youth whether on the farm or in the town is incomplete without some knowledge of the part agriculture plays in human affairs. It is hoped that the wider knowledge thus acquired will tend to counteract the drift to the cities and result in a better balance in every phase of our national life. Agriculture, therefore, is included in our Course of Study, because it is a basic industry in our civilization, not because Saskatchewan happens to be an agricultural province. The subject thus regarded can scarcely be called vocational or even pre-vocational. It is simply educational.

From this standpoint, Agriculture cannot be treated in a technical way especially in the lower grades. It is more the attitude of mind that is of value than the material used. It implies the fullest use of the environment in teaching drawing, arithmetic, language, etc. The foundations of geography are laid in the study of convenient land and water forms and weather observations. The inter-relationship of plant and animal life gradually comes to view as the common living things are watched and studied. From the beginning, the natural inclinations, keep pets and work in the soil, are utilized in developing the powers of observation and expression.

Toward the middle period of the public school life, the work assumes a more practical phase with the introduction of school gardening. The purpose of the garden is not the growing of produce but the

development of the child. Here, at first hand, he learns in some measure how to control the great processes of nature and achieves the joy of creation. The garden becomes a laboratory and the study of plant and animal life proceeds from a new angle.

In the upper grades the work assumes a scientific phase. The pupil draws conclusions from his own experience and that of other pupils. Laws are discovered and experiments devised for further and more thorough investigation. At this point a whole new range of study opens up. The relation of plant and animal life on the farm, the place of machinery, marketing, farm management and the more general problems of production come under review. Not only is the experience of the pupil studied but his information is organized and related information sought and incorporated.

What success has attended the effort? As far as examinations are an indication of success, progress is being made, but the greater and more important part of the work cannot be measured in this way. General conditions in the province do not favour the development of gardening on the school grounds but there is a constant increase in the use of the home plot. The school exhibition, while not essential to the course, serves to indicate what is taking place. Each year the quality of vegetables and grains exhibited improves, showing at least a better knowledge of standards and more careful selection. The projects conducted by the boys' and girls' clubs, however, give the best indication of progress as here we find the school definitely linking its activities with the home life. The increase in the number of pupils engaged in this work is quite gratifying when it is remembered that no grants are paid by the department and all expenditures must be borne locally.

As in all phases of school work, the ultimate success depends on the teacher. It is gratifying to note that an increasing number of teachers realize the true place of agriculture as a school study and are doing everything in their power to give the boys and girls a better appreciation of this great fundamental industry.

The value of such a course cannot be easily determined. Its success cannot be measured from the practical standpoint since it does not attempt to train in the practice of farming, neither can it be seen in the development of scientific farmers. Its effect must be sought in the better relationship between town and country, in the appreciation of the great place agriculture plays in human life and in the widespread acceptance of agriculture as an occupation worthy of the best brains and training in the community. To determine whether this ideal is

being achieved requires time and it is yet too soon to attempt an answer.

The portion of the Agricultural Instruction Grant allotted to the Saskatchewan Department of Education has been expended in the training of teachers and in giving personal guidance and assistance in the development of every phase of activity which will make the course more efficient. As noted above, no grants are given in the Elementary schools either to teachers or schools doing the work or towards the conduct of school fairs. Consequently, what progress has been made is natural and it is hoped of permanent value. -*The Agricultural Gazette of Canada, Vol. IX, No. 6.*

VI

A Useful Plant for India.*

While engaged in research work at the Standford University, California, I had to look up references regarding a tree commonly known as Mesquite or Algaroba and was so impressed with its usefulness that I decided to take seeds with me to India. The tree is a native of Brazil but is either indigenous or cultivated in Argentine, Chile, Peru, Bolivia, Columbia, Central America, Mexico, Texas and the West Indies.

In Hawaii, where I had opportunities of observing the habits of the tree, it was introduced by a missionary in 1828. Since then it has spread over the islands, and now occupies in Oahu alone no less than 100,000 acres. The tree is, however, confined to the leeward portions of the island where it thrives from the sea coast up to an altitude of 2,000 feet. In this part of the island rainfall is scanty and in places so little that the localities may be little different from semi-arid desert. The windward side of the islands have, however, a different climate owing to the trade winds which blow practically throughout the year. Rainfall varies from 200 to 400 inches. Here the tree is but rarely found.

The Mesquite is a legume belonging to the Genus Prosopis which is represented by but two species in India. The following is the scientific description of the plant Prosopis juliflora :—

"A tree 10 to 20 m. tall, branches glabrous or minutely puberulous ; stipules small setaceous or aristate, sometimes obsolete ; spines axillary, solitary or in pairs, straight, in sterile branches up to 5 cm. long, devaricate, sometimes very short or entirely absent ; leaves glabrous or rarely pubescent, distant or in short branchlets, subfasciculate, common petiole 12 to 50 mm. ; glands often small between the pinnæ, and smaller between

* We are indebted to the Agricultural Adviser to the Government of India for the loan of block illustrating the article. The illustration is printed as frontispiece in this issue.—Ed.

leaflets; pinnæ often 1-jugate, rarely 2-jugate, very rarely 3-jugate; rachis 3.25 to 7.5 cm.; leaflets broadly oblong 4 to 6 mm. long, or linear 12 mm. to 2.5 cm. long, with intermediate forms straight or falcate, obtuse or pointed, the costa somewhat prominent beneath; inflorescence spicate, axillary or fasciculate with the leaves, shortly pedunculate, 5 to 10 cm. long, dense or slender and subinterrupted; bracts minute, flowers glabrous outside or with few short scattered hair, 3 mm. long, calyx 1mm. long, the opening often ciliate, petals are often woolly inside at the apex; stamens half as long again as the corolla; ovary shortly stipulate, villose; pod more or less arcuate or nearly straight, 5 to 15 cm. long, 4 to 12 mm. wide, before maturity often flat compressed, at maturity on both sides more or less convex, continuous outside, or between the seeds marked with depressions of transverse lines, mesocarp more or less spongiose, endocarp hard, often bony."

The tree is very variable. In Texas it is little more than a shrub but further south in Mexico it grows into a large tree often attaining a height of 45 to 50 feet with a diameter of about 2 feet. The roots go down to great depths after water. This latter feature makes it specially adapted for growth in regions with scanty rainfall.

The flowers have a sweet scent and the flower spikes are from 4 inches to 6 inches long. There are two flowering seasons, one in April and the other about October. The pods are from 6 to 10 inches long and have a thick spongy pericarp containing syrupy matter. They turn yellow when ripe and drop to the ground. They are of high nutritive value and much relished by all kinds of stock. Children in Texas also eat them. The pods are collected and ground to serve better as cattle food. The crop in the island of Oahu alone is estimated at 25,000 tons annually and a factory has been established there to deal with this enormous output.

The value of the tree does not consist in the pod alone. The long flower spikes yield honey in abundance and in some parts of Texas and Hawaii this is the only source of honey for the large number of beehives kept. They produce an abundance of pollen. Out of the 600 tons of honey produced in Hawaii about 200 tons are derived from Mesquite alone. A tree of about 30 feet spread is estimated to produce 2½ pounds of honey.

One advantage the tree has over most other honey-producing trees is that it blossoms twice in the year, once about April and again in October. The April blossoms last till August so that save for a short period of about two months there are flowers nearly the whole year. A fairly continuous

supply of honey is assured to bees. A second feature is that, provided there has been rain in the latter part of the year, there will be an abundance of flowers the next year no matter how dry the following summer is.

When grown to its full height the Mesquite is a very graceful tree and serves well as an ornamental tree in parks. The illustration is from a park in Honolulu. The wood takes a fine polish and is therefore used for furniture and cabinet work.

From the description given above, the value of the tree to India is obvious. Provided it can be naturalized—and there can be no doubt from the wide range of its habitat that it can be—it will go far to solve the problem of cattle famine. The large yield of pods averaging to 200 to 300 lbs. will provide a source of highly nutritive food especially in localities where from want of rain the cattle are liable to starvation. The adaptability to semi-arid regions makes it specially valuable. There are large tracts in India of this description where the tree may usefully replace other trees now growing wild or grown solely for firewood.

The Mesquite is equally important as a source of honey. One great obstacle to extensive bee-keeping in India is the scarcity of honey-yielding plants in the plains. As a result indigenous bee-keeping has been confined to the hilly tracts where the drawback does not exist. With the introduction of the Mesquite there will be provided a continuous source of honey for the greater part of the year.

A large number of seedlings have been raised in Bangalore* from the seeds brought down from Hawaii. They seem to thrive well but their behaviour in their new home is yet too early to forecast. The tree is very variable as has been mentioned already. It is possible that it will exhibit the same variation in India as it has in other parts of the world. But whatever the variation, its great value as a source of highly nutritive cattle food is not likely to be diminished under the different conditions of this country. *The Agricultural Journal of India, Vol. XVIII, Part II.*

NOTE.—Since the acceptance of the article for the Journal (*Agricultural Journal of India*), I have been informed by Rao Bahadur Rangachari, Lecturing Botanist at the Agricultural College, Coimbatore, that he saw several of these trees fairly full grown in a sandy tract near Madras and the appearance showed that they were thriving well. The possibility has occurred to me, therefore, of the introduction of the plant in other localities in India, more especially in parks and botanical gardens. If my surmise is correct, there is already valuable experience available of the behaviour of the tree under Indian conditions, and I trust those who have it will make it known to the public through the medium of this Journal. (K. K.)

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* Some three hundred of these are growing on the Hebbal Farm near Bangalore. A good number of seedlings are being grown by our members. Dr. Kunhi Kannan expects a fresh supply of seed from America by about the end of August this year.—ED.

VII

Metallic Mercury as an Insecticide.

Dr. K. Kunhi Kannan of the Department of Agriculture of Mysore State, while visiting our laboratory in 1920, mentioned the fact that he had successfully prevented the hatching of Bruchid eggs in India by placing a small amount of metallic mercury in the container. While he was unable to give the identity of the Indian Bruchid, he said that it glued its eggs to the bean as does B. "QUADRIMACULATUS." He said that, without the mercury appreciably decreasing in quantity, its presence in a container completely prevented the development of the eggs. He said that this action of mercury had been a tradition among his people.

As a result of this information three experiments with mercury and the eggs of B. "QUADRIMACULATUS" were carried on at the same time, as follows :—

1. A pint of black-eyed cowpeas in a quart Mason jar were oviposited upon by a few females on September 21 and 22, 1920. On September 22 about a thimbleful of mercury was sprinkled into the jar and the lid screwed on. Shortly after a paraffin rubber ring was put on to exclude mites (*pediculoides ventricosus*), but this was removed on October 18. The beans were examined on November 5. They were spread out and examined carefully with a reading glass. Infestation being light, only forty (40) eggs were found, and these were examined under the binocular. No embryos had developed. Marked preference was shown by the parent weevils for black-eyes with fewest wrinkles.

2. September 20, two thimblefuls of mercury were placed in a small vial with a hole in the cork and the vial placed upright in a pint of black-eyed cowpeas in a quart Mason jar. Twenty-three (23) B. QUADRIMACULATUS were put in the same day. More weevils were put in September 22. Shortly after, a paraffined rubber ring was put on the jar ; this was removed on October 18. Examination of the beans was made on November 5, the beans being gone over carefully with a reading glass. One hundred and thirty-five (135) eggs were picked out and examined under the binocular with the result that no embryos were found to have developed.

3. Twenty-two black-eyed cowpeas with thirty-nine (39) newly deposited eggs were put in a small vial with one thimbleful of mercury These eggs were laid on September 20–23 and were put in the vial with

the mercury on the 23rd. The vial then was sealed with a paraffined cork. Examination on November 5 showed that no embryos had developed, the egg shells being dry and empty without exception.

Small spots of black mold were found on the beans in all the containers. The paraffined rings and cork were thought advisable to exclude mites, but may have influenced the results. Later duplications of the above experiments, without using paraffin and rubber rings gave the same results, as far as the failure of the eggs to develop is concerned. In these no mold appeared.

On July 22, 1921, several weevils, B. QUADRIMACULATUS, were put into a quart Mason jar of clean red ripper cowpeas. The next day, after oviposition had taken place freely, the eggs were examined with the aid of the binoculars, and all eggs that were not properly glued to the seed coat or that appeared to be imperfect in any way were discarded. One hundred (100) were placed in a vial, 3.2 x 10 cm. and an equal number was placed in a similar vial. These eggs were perfect as far as it was possible to determine. Into one vial was placed a little vial 1.7 x 6.5 cm. containing about 1 cc. of mercury. The smaller vial containing a perforated cork was placed upright and the larger vials were set aside for observations.

In one week it was noted that eggs in the one vial were hatching, while those in the other were not. In another week it was observed that the larvæ from the eggs in the one vial had almost all entered the cowpeas, while in the other vial not an egg had hatched.

On August 15th, after removing the vial of mercury, it was found that every egg that had been in the larger vial, along with the mercury, had shrivelled up and appeared to have nothing inside of the chorion. These eggs were remarkable for the absence of all contents within. They were absolutely hollow. There was nothing to indicate that development had ever begun.

On August 16th the cowpeas in the other vial were dissected and four live pupæ, 74 live larvæ and 8 dead larvæ were found within. 86% of the eggs had actually produced larvæ, and others showed embryonic development, while in the other vial there appeared to be absolutely no embryonic development. No mold appeared in either vial.

On July 25th several pairs of weevils, B. QUADRIMACULATUS, were placed in a jar of red ripper cowpeas. These weevils oviposited freely,

covering the cowpeas with varying numbers of eggs up to 15 or more, but averaging 8 or 9. Most of the weevils died before August 15th, and the greater number of eggs were laid during the early part of the period from July 25th to August 15th ; in fact, many of the eggs had hatched and the larvæ had entered before the latter date.

On August 15th two hundred of the cowpeas were counted out and placed in two vials 10 x 3.2 cm. Into the one vial was put a small vial (1.7 x 6.5) containing about one-half thimbleful of mercury. The cowpeas were arranged around the small vial which contained a perforated stopper. Tight stoppers were placed in both large vials, and they were placed side by side on a shelf for observation. For convenience they were labelled "mercury vials" and "check vial."

In a short time it appeared that weevils were at work in the "check vial," because borings and frass began to exude from the cowpeas. It soon became evident that the lack of proper ventilation in this vial was being felt by the weevils. They made openings through the seed coat, and three half-grown larvæ left the cowpeas and died. By October 29th, mold began to appear in the vial. This mold developed so rapidly that it was feared that it would kill all the enclosed weevils ; therefore on November 4th these cowpeas were placed in four clean dry vials similar to the original. These vials were laid down so that the cowpeas could have an opportunity to dry and retard the development of the mold. On November 7th, adult weevils began to emerge. The vials were examined daily and all emerged adults were removed. On December 9th, after 101 adults had emerged, it was found that the vials were becoming infested with mites, PEDICULOIDES VENTRICOSUS, which made it necessary to kill all within the vials. The cowpeas were then dissected and the contents tabulated.

Within the "mercury vial" there seemed to be no activity. No borings or frass exuded from the cowpeas ; no larvæ bored openings in the seed coats, and there was no evidence of the lack of proper ventilation. On October 6th, when it was thought that all the weevils were dead, seven cowpeas were dissected. The last one contained two half-grown larvæ which were alive but were very inactive. The remaining 93 cowpeas were set aside for further observation. On December 9th a very small amount of mold appeared in the vial. By January 11th the mold had not increased to any appreciable extent, and no weevils had emerged ; so the cowpeas were dissected and the contents tabulated. At this time all the weevils were dead.

No. of cowpeas	Treatment	Adults				Larvæ				
		No. of Eggs	No. Hatched	No. Emerged	No. Unemerged	No. Pupae	No. Fullgrown	No. Halfgrown	No. Fourth-grown	No. Less than ¼ grown
100	Mercury ..	800	643	0	0	8	20	86	244	292
100	Check ..	920	814	101	79	61	29	82	154	367

The above table shows that in the mercury vial only 20 larvæ became full-grown and only 80 more became half-grown, while in the check vial 101 adults emerged, 79 were ready to emerge, 61 had become pupæ. While all weevils in the mercury vial died, and while only 101 emerged from the other vial, there is no doubt that most of the unemerged adults and pupæ, and many of the larvæ from the check vial would have emerged if the mites had not made it necessary to kill them.

In the foregoing experiments the presence of the mercury was the only thing that could possibly have caused the eggs and larvæ to fail to develop. Only in one case was the mercury in contact with cowpeas, and then it was not in contact with the eggs. The mercury did not seem to diminish in amount, and as Dr. Kannan said "It could be used over and over again with no apparent loss."

While the foregoing may not be of practical use in warehouses because of the initial cost of the mercury, it is of scientific interest and may be put to use as an economical means of combating other insects. The writer has not had an opportunity to try it against clothes moths, but he can see no reason why a vial of mercury in a trunk or closet would not be effective in preventing the hatching of the moth's eggs. If later investigation shows that it will prevent the hatching of these eggs, it would be economical and convenient method of control, because the initial cost of the mercury would be little, and it would require practically no attention after placed in the desired location.—*Journal of Economic Entomology, Vol.* 15, *No.* 6.

VIII

Rothamsted and Agricultural Science.

The Rothamsted Experimental Station has just passed its eightieth year, having been founded in 1843. Its study has always been the growth of crops, with periodical excursions into problems of utilization; the

method of experiment has always been essentially statistical in that the field experiments were repeated year after year without modification, with the result that a unique mass of data has now accumulated which is proving of the greatest value for statistical investigation.

The work at Rothamsted falls into two great periods: the first, when Lawes and Gilbert were actively exploring the possibilities opened up by the knowledge of plant nutrition gained by the early nineteenth-century workers; and the more recent period, when close study of the soil has revealed certain factors of high scientific interest, and, one is constrained to believe, ultimately, of great practical importance.

The great problem which Lawes and Gilbert set out to solve was to account for the fertilizing value of farmyard manure. The fact was well known, but there was no satisfactory explanation. Lawes and Gilbert proceeded by a method that still—after eighty years—remains our best. It was known that farmyard manure contained three groups of components: organic matter; nitrogen compounds; and ash constituents—potassium, calcium and magnesium salts, phosphates, silicates, etc. They therefore arranged vegetation tests with these various groups. The old idea was that the fertilizing value lay in the organic matter, but Liebig, in 1840, had argued brilliantly against this view, and suggested instead that the ash constituents, especially the potassium, calcium and magnesium salts, were the effective agents. Lawes and Gilbert were prepared to recognize the necessity for these mineral salts, but insisted that the nitrogen compounds were equally required. To put the matter to a test, they laid out four plots of ground, receiving respectively no manure, farmyard manure, ashes of an equal amount of farmyard manure, and these ashes plus a nitrogen compound (ammonium sulphate). The results were as follows:—

Produce of Wheat per acre, Broadbalk Field, Rothamsted, 1844.

	Grain (bushels)	Straw (cwts.)
No manure	16	1120
Farmyard manure (14 tons per acre) ..	22	1476
Ashes of 14 tons of farmyard manure ..	16	1104
Ash constituents plus nitrogen compounds and ammonium sulphate up to	26¼	1772

They concluded that farmyard manure owes its value, not to the organic matter as was for long supposed, nor to the ash constituents as Liebig had suggested, but to the ash constituents plus nitrogen compounds.

Now this discovery was of the greatest importance in plant physiology but Lawes and Gilbert did not follow it up in that direction. Instead, they applied it at once to an important agricultural problem then ripe for solution. There was then (as nearly always now) a shortage of farmyard manure on farms, and agriculturists had for generations sought for substitutes, but with little success. Lawes and Gilbert saw that the mixture of ash constituents and nitrogen compounds would form an effective substitute, and further, that it could be obtained in very large quantities, and of course independently of farmyard manure. Geologists had discovered vast deposits of calcium phosphate, which chemists had shown how to render soluble. Engineers were developing the manufacture of coal gas and producing large quantities of ammonium sulphate, while potassium compounds could be obtained without difficulty from wood ashes. Lawes and Gilbert therefore proceeded to make mixtures of these substances which they advised farmers to use.

Few experiments have proved so fruitful in stimulating scientific inquiry—it is still opening up new fields at Rothamsted—and in ministering to human needs, as this simple field trial carried out eighty years ago on the Broadbalk field at Rothamsted. At first farmers looked with some misgiving upon this new kind of manure (which was called "artificial manure" to distinguish it from farmyard manure then known as "natural manure"); it seemed incredible that a harmless looking powder without smell or taste could act as potently as the old time richly odorous farmyard manure. But they soon came to recognize its value, and before long they were using many thousands of tons a year. It is safe to say that the remarkable development of British agriculture which took place between 1843, when Rothamsted began, and 1870, would have been impossible without artificial fertilizers. During that period British farmers kept pace with the growing needs of the population; indeed they did more, for they helped to change the "hungry forties" into the more plentiful 'seventies'. The use of artificial fertilizers is now developed throughout the civilized world and the industry has attained enormous dimensions.

This was the greatest achievement of Lawes and Gilbert. They did many other things for the farmers of their day, but this alone leaves us owing them a great debt of gratitude.

As the use of artificial fertilizers spread there arose, as one might expect, many problems of great scientific interest or technical importance. Thus it soon appeared that weather conditions profoundly affected the response of crops to artificial fertilizers. The same fertilizer mixture

which in one season gave results fully equal to, or even surpassing those of farmyard manure, would, on the same farm and even in the same field, prove a failure in another season. This is well shown in the fluctuations in yield on the Broadbalk wheat field at Rothamsted.

The effect of soil is also sharply marked. On our heavy soil at Rothamsted the best results are usually obtained by a fairly liberal use of phosphates, but there is less necessity for large dressings of potash. But on the much lighter soil of Woburn potash is considerably more important, while phosphates are less needed, and, indeed, beyond a certain quantity appear to do actual harm. It is obvious, therefore, that a complete manure drawn up on the basis of the Rothamsted experiments would fail in practice to give the best results on a lighter soil. As an instance the following may be quoted, this being one of the general scheme of experiments organized from Rothamsted :—

Barley : Light sandy soil in Suffolk, 1922.

	Bushels per acre
Complete artificial manure	21.5
Incomplete manure : phosphate omitted	27.5
No manure	16.0

In this instance the omission of phosphates has raised the yield by 6 bushels per acre. As against this, an array of instances might be brought from clay farms where a phosphate is the one and only thing that causes crop increases. Any one who had to deal with farmers' problems could multiply apparent contradictions and inconsistencies of this kind. When one collects, as we have done at Rothamsted, the results of field trials with artificial manures made in different parts of the country, they seem at first to be simply a tangled mass of unrelated facts.

Now it is the business of the man of science to sort out a tangle of this kind, to reduce it to order, to find the general principles running through it, and finally to prove the correctness of his conclusions by being able to predict with certainty what will happen in given conditions. The recognized method of procedure is to discover the various factors at work and investigate them one at a time. This is being done at Rothamsted in two ways : by field observations, and by quantitative laboratory measurements. Observations in the field show that each of the fertilizing substances—phosphates, potassium compounds, nitrogen compounds, etc., in addition to its general effect in increasing plant growth, produces certain specific effects which may be of advantage, or may be a disadvantage to the plant in the particular conditions in which

it happens to be growing. Thus, phosphates have a special influence in hastening the ripening processes, which no doubt accounts for the Suffolk results just quoted. In the dry conditions of a sandy soil, ripening is already too early, and any reduction in an already short growing season cuts down the yield; in cold, wet districts, however, this property is very valuable.

In the early stages of the plant's life phosphates stimulate root development to a marked degree; this is well shown in their effect on Swedes. Nitrogen compounds tend to increase leaf development and give greater vigour of growth, but beyond a certain point the advantage is counteracted by a loss of resisting power, and the plants may fall victims to attacks of disease. Crops—especially cereals- may be unable to stand up against the weather and may become "lodged". Indeed, the proper adjustment of plant nutrients affords plant pathologists one method of dealing with plant diseases.

Qualitative observations of this kind, while of high value, are not entirely sufficient: it is necessary to have quantitative measurements of as high an order of accuracy as possible. At Rothamsted this is done by means of water cultures and pot experiments; all the factors are controlled as closely as possible and the results are plotted on curves which can be studied in detail. This method was developed extensively by Hellriegel and is now in common use in agricultural laboratories.

The method naturally invites mathematical treatment, and attempts have been made notably, by Mitscherlich, to express the curve by equations. There is a seductive look about a mathematical formula which rarely fails to appeal to the biologist, but as a rule the number of experimental points obtained is much too small to justify mathematical treatment, and it is not surprising that investigators fail to agree. Ten years ago the fashion was for logarithmic curves: now it is for sigmoid curves, which are probably nearer the truth, though not yet a complete expression.

This method of studying single factors is pushed to a high degree of refinement in plant physiology laboratories, such as that of the Imperial College under Prof. Blackman, or that under his brother at Cambridge, and there can be little doubt that the effect of individual factors on the plant will ultimately be well known. All this work is giving valuable information as to causes and principles.

These curves show the relationship between yield and plant food supply at one particular temperature which remains constant, and one particular water supply which also remains constant. But a completely different set of figures would be obtained if the temperature were different

or if the water supply were altered. Supposing one wished to take account of the effect of water supply as well as food, one would draw a series of curves, which would properly be expressed as a surface and this has been done by one of the Rothamsted workers—Mr. J. A. Prescott—to show the effect of nitrate supply and spacing on the yield of maize in Egypt. The experiments had the advantage that the climatic conditions are less fickle there than here. It would be of the greatest interest to obtain such surfaces for other pairs of factors.

If an attempt were made to study factors three at a time, it would be necessary to prepare a series of surfaces and to embody them in a figure in four dimensions, which is certainly beyond the capacity of the ordinary agricultural investigator. But in agricultural field work the factors do not vary one at the time, or even two or three at the time ; there may be half-a-dozen variables. This, of course, enormously complicated any attempt to apply to field conditions the results obtained by these single factor physiological experiments. It is possible that when the physiologists have completely elucidated all the single factors, some one will be able to synthesize the material and build it into some great conception or expression that will contain all and thus account for the field results. But history shows that the genius capable of effecting a synthesis of this sort is very rare and might have to be awaited long.

We have therefore adopted another method of Rothamsted, which is being worked alongside of the single factor method. Statisticians have, during recent years, been evolving methods for dealing with cases where several factors vary simultaneously. These methods have been applied by Mr. R. A. Fisher to the Rothamsted field data, and has been able to trace certain statistical regularities, which foreshadow the possibility of important developments.

Thus the yields on the Broadbalk wheat field vary every year, apparently in a most erratic manner. But an analysis of the figures showed that the factors causing variation could be disentangled and expressed quantitatively ; there are slow changes in the field, such as changes in the amount of weeds, etc. ; deterioration of soil, and weather changes such as rainfall, temperature, etc.

As might be expected, the effects differ according to manurial conditions ; *e.g.*, the influence of weather varies with the manure. Important differences appear between farmyard manure and artificials. The variation in yield is less where farmyard manure is given than where artificials are used. Further, the so-called complete manure appears not really complete at all ; there is soil deterioration going on ; but with

farmyard manure no such deterioration is produced. The different kinds and quantities of artificial manures produce different effects on the variation in yield, the magnitude of which has been worked out.

Having disentangled the factors Mr. Fisher has proceeded to analyse the effect of rainfall, and he finds that part of the weather effect is predictable when rainfall is known. Rain above the average in autumn is somewhat beneficial ; in winter and in summer it is harmful, and in spring it is less frequently harmful. As before, the effects are much more pronounced with complete artificials than with farmyard manure. The actual facts have long been known in a general way, but here is an exact quantitative measurement.

The great advantage of this statistical regularity is that it indicates the possibility of expressing in terms of chance the influence of the weather, soil, etc., on crop yields. We hope ultimately to be able to say to the farmer, given such and such conditions of soil and weather the chances are so many to one that such and such an increase of yield will be obtained by the use of a specified fertilizer. The expression would be understood by every farmer, and he would readily decide whether to take the risk or not.

Much greater results would also follow. At present the farmer cannot cover his risks of low yields by insurance, the companies not yet having sufficient data. We hope and believe that these statistical investigations will afford the basis on which such data will be obtained. At present the position approximates to that of life insurance in the eighteenth century, when the statistical regularity of mortality was first established, after which the first life tables could be constructed. There still remains a mass of detail to work out, but the fundamental problems are now being attacked, and we see no reason to regard them as insoluble. If the expectancy of crop yields proves to be calculable the farmer will be able to insure himself against crop failure, and so meet one of the worst vicissitudes of his troubled life by merely taking out an insurance policy—perhaps even by subscribing to a particular newspaper.

We are not in a position to give an absolute clear cut prescription to any farmer, but we are going a long way to meet him. Some of our field experiments of special interest or importance are being repeated at other centres where soil and climatic conditions are all different. The results are compared with ours, or with others that have been obtained, to ascertain how far or in what direction any of our conclusions would need modification in a particular district.

We now return to an important result to which I have already referred. Over a period of years the artificial manures have not proved quite as effective as farmyard manure; there has been more variation in yield and they have not so well maintained the fertility of the soil as farmyard manure has done. On some crops the effect is marked; clover responds better to farmyard manure than the artificials. It appears then that Lawes' and Gilbert's view that the fertilizer value of farmyard manure lay in its ash constituents plus nitrogen compounds is only a first approximation, and that farmyard manure does something or contains something which artificial manures do not. This difference we are now engaged in exploring.

The same method of procedure is used as in studying the effects of artificial fertilizers. A full scientific investigation into the causes is carried out, but simultaneously an attempt is made to find some working solution of the farmers' problems. The shortage of farmyard manure is still as acute as ever, and to keep more animals with the view of making more is uneconomic. At Rothamsted we have attempted to produce farmyard manure from straw artificially and without animals. This has been done by Mr. E. H. Richards and Dr. Hutchison by stimulating the essentials of the natural process, namely watering straw with a salt of ammonia (actually ammonium sulphate, but calcium carbonate is mixed with the straw), and leaving the heap so that the air can get in and the organisms can do their work. The product is not yet equal to the natural substance, but it is steadily being improved, and the very serious difficulties are gradually disappearing in Mr. Richards' competent hands. Five years ago a few ounces only of this artificial farmyard manure had been prepared; last year several thousand tons were made on various farms in different parts of the country, and the news is spreading. The serious problem of developing the work from the laboratory to the farm scale has been possible through the generous and public-spirited action of Lord Elveden. There seems here the possibility of aid to the farmer and of the development of an important new industry.

Meanwhile a full scientific investigation is being carried on to discover wherein farmyard manure differs from artificials. One important difference is already known and is being investigated by Dr. Keen. Farmyard manure opens out the soil particles leaving bigger pore spaces; it allows of the retention of more moisture and the better circulation of air. All these effects are beneficial.

There is also another difference. Farmyard manure and also plant residues (which are substantially the same thing) decompose in the soil,

giving rise to many substances of different types. The plant foods are among the end products; indeed, in natural conditions and, to a large extent, in farms and gardens also, it is in this way that plants obtain their food. In using artificial manures we supply these end products at once instead of waiting for them to be liberated gradually by the natural decomposition. Further, we do not by any means know the whole of the processes whereby plant food is made. But there are certain intermediate products, and it is quite possible that some of these may have a special effect on the growing plant. Curious stimulating effects are produced by substances formed when soil is steamed, or when oxidation is accelerated by addition of charcoal, and we have obtained the same results with small quantities of picric acid: such bodies might well be formed as intermediates in the decomposition of farmyard manure. The whole effect suggests an action like that of the vitamins of plant physiologists or the auximones of the late Prof. Bottomley. The chemical department at Rothamsted, under Mr. Page, is following out the process, and the botanical department under Dr. Winifred Brenchley, will test any intermediate products which may be obtained.

A further important factor, which probably governs the whole situation, is that a great part of the process of decomposition and plant food production appears to be brought about by living organisms in the soil. Simultaneously, therefore, with the chemical and botanical investigations, the various biological departments are busily engaged in studying the organisms that are doing the work.

It is a wonderful story that is being revealed. The soil is shown to be the abode of a vast population of living organisms of the most varied kind. Some of them are remarkably small; among them one which brings about the last stage in the formation of nitrates—an organism which Rothamsted just missed forty years ago; another, also just missed at Rothamsted, which has the remarkable property of fixing nitrogen in the nodule of the clover plant. Others are larger and more easily picked out, but their exact place in the soil economy is not easy to determine: probably they are concerned in the preliminary stages of the decomposition.

It is impossible to peer into the soil with a microscope, so that indirect methods of exploration have to be used. At Rothamsted the organisms are counted and the work they do is estimated by some chemical process; a single census is not of much use; it is not until several have been taken that one can find how the numbers and activities of the population are being affected by various conditions. The census is

therefore repeated periodically and the results are plotted on curves from which it is possible to deduce the effect of various factors on the particular organisms counted.

These curves brought out the remarkable result that partial sterilization increased bacterial activity, and investigation showed that the normal virgin soil must contain other organisms besides bacteria—organisms, moreover, which were detrimental to bacteria and tended to keep their numbers down. A search for such organisms showed that protozoa were present: many forms have since been found in the soil, some of which are known to feed on bacteria. Mr. Cutler has discovered how to count them, and with the co-operation of willing workers has succeeded in carrying out perhaps the most remarkable census yet made of the bacterial and protozoan population of a natural field soil. Before the census began many months were spent in perfecting the methods and technique, and in making preliminary studies of the soil. The details were carefully arranged with the statistical department, and it was decided to take the census many times at short intervals. Time to a bacillus or a protozoan is a different thing from what it is to us, and instead of taking the census every ten years, or even every ten days, it was taken daily, and at the same hour every day. Many repetitions were needed so that the statistician might feel safe in drawing conclusions from the data. The census was therefore made every day for 365 consecutive days, and no less than seventeen different organisms were enumerated.

A team of five workers kept the investigation going without intermission—Sundays, Bank Holidays and Christmas Day—for a whole year. A mass of data was obtained of high statistical value which is proving of the greatest importance in the study of the soil population. One of the most interesting results was the proof that the soil population is not steady in number as had always been assumed, but is in a violent state of flux. Every organism observed protozoan or bacterium showed great daily variations, which seemed to be independent of external conditions. At least one showed a two-day periodicity. The fluctuations of the amœbæ were of special interest as they were exactly the reverse of the bacterial fluctuations. Close examination of the curves leaves no doubt that the fluctuations of the amœbæ cause the fluctuations of the bacteria, high numbers of amœbæ causing low numbers of bacteria, and low numbers of amœbæ allowing bacterial numbers to rise; but why the amœbæ fluctuate remains a mystery.

In the case of bacteria it has been possible to make even closer obser-

vations. A census organized by Messrs. Thornton and Page has been taken each two hours for several days and nights; but again the same wonderful fluctuations are seen. As might be expected, the amount of work, as measured by the nitrate present, alters from hour to hour. But the curve was not quite what was expected: the increases in amount of nitrate could be understood as representing the work done by bacteria, but the decreases were more difficult to explain. There was no rain to wash it out and there were no plants to take it up; yet the nitrate tends to disappear. The results suggest that some organism is absorbing it. Algæ and fungi could both do this, and both are found in the soil: Dr. Muriel Bristol and Dr. Brierley are closely studying them.

Perhaps even more remarkable than the daily changes are the great seasonal changes. It appears that the whole soil population is depressed in winter and in summer, and is uplifted in spring and autumn. How this comes about we do not know. The phenomenon does not seem to be confined to the soil; the algæ in a pond and the plankton in the sea, like the organisms in the soil, all seem to feel the joy of spring: it is as if Virgil had got hold of some great truth in natural science, which we have not yet been able to express in cold scientific terms, when he says that in spring "Acther, the Almighty Father of Nature, descends upon the earth, and blending his mighty frame with hers, gives life to all the embryos within."

The number of organisms in one single gram of soil—no more than a teaspoonful—often well exceeds 40 millions. This looks big, but it is difficult to form an idea of its immensity. If each unit in the whole array could be magnified up to the size of a man and the whole caused to march past in single file, they would go in a steady stream, every hour of the day and night for a year, a month and a day, before they had all passed. We must think then of the apparently lifeless soil which we tread beneath our feet as really throbbing with life, changing daily and hourly in obedience to some great laws which we have not yet discovered: pulsating with birth, death, decay, and new birth. And if the wonder were not sufficient, we know that in some way these lowly organisms are preparing the food for our crops—the crops on which we ourselves feed. It is possible—it is even probable—that our attempts to learn something of this wonderful population may lead to some degree of control which would have valuable economic results. But even if this never happened the work would still be justified because it shows to the countryman something of the abounding interest of his daily task and of the infinite wonder of the soil on which he spends his life.—*Nature, Vol. III, No.* 2788.

The Mysore Agricultural and Experimental Union.

Instructions for Conducting Sugarcane Varietal Tests.

To get reliable results from the experiments much care is needed to conduct the trials. The object of the trial is to find out better varieties of sugarcanes to suit the various conditions of soil and climate in the State. As a result of careful experiments conducted over a series of years, new varieties of sugarcanes have been evolved at Hebbal from seeds. Some of them are very promising and a few of them have already begun to give heavy yields of cane and jaggery in different parts of the State. They give heavy tonnage of canes, contain plenty of sugar and produce good jaggery. By extending the area under these canes one would be adding greatly to the wealth of the country.

For conducting the trials a fairly level field with a uniform soil and thorough drainage are essential. The whole plot should have been cropped with one kind of crop in the previous season. There should be a good supply of water for irrigation. The cultivation and manuring should be uniform for the whole plot. In no part of the day should there be any heavy shade on the plots. Planting of setts should be done early in January or as early as possible in the season. Rows should be about a foot deep and be spaced 3 feet apart. Each sett should contain about three buds. Setts should be planted at the bottom of the furrows with the buds facing sideways, in a line, at intervals of a few inches and lightly pressed into the soft earth so that they may be buried just a little below the surface. As the canes grow, the furrows should be gradually earthed up. Manuring should be given at the time of first earthing and when the crop is not later than 5 months old. Wrapping should be done twice or thrice according to growth to prevent the canes from lodging and to keep away rats and jackals. After the second wrapping any fresh shoot that comes out should be removed while weeding. When the canes have grown for about eleven months request your Agricultural Inspector to come and test your crop. If the canes are ripe, harvest the canes and compare the yields of different varieties. Continue the trials at least for two or three years. The variety that does best in most of the years is the one that is probably best suited for your place. At the time of harvest tabular forms will be supplied for recording correct information. A judicious use of the forms will be very helpful in the sugarcane extension work.

Request the Director, Deputy Director, Assistant Director or Agricultural Inspectors in December or January to get you these new canes

3 rows Local Cane Non-Expt.
3 rows Local Cane
3 rows H. M. 544
3 rows H. M. 320
3 rows Local
3 rows H. M. 544
3 rows H. M. 320
3 rows Local
3 rows H. M. 544
3 rows H. M. 320
3 rows Local
3 rows Local Non-Expt.
21 ft.
108 ft.
Rows 3 ft. apart.

in time. Prepare and have your lands ready in the manner suggested above. You may receive 200 setts each of one or two varieties. Plant them as shown in the diagram.

Each row may be planted with 20 setts. The area covered by three rows will be about 1/230 part of an acre or roughly $\frac{1}{6}$ of a gunta in area. Both ends of the field should be planted with three rows of local cane. The experiment should start with three rows of local cane and three rows of each of the varieties should be repeated at least three times and the experiment should end with three rows of local cane. If the plots are arranged and sown in this manner you will be making allowance for all variations in the soil. The total area required for the experiment will be about 1/19 acre or a little over 2 guntas, having a dimension of 21 feet by 108 feet. If there is any difficulty for you to lay out the plot, a requisition from you will get you the aid of the nearest Agricultural Inspector. [V. K. B.]

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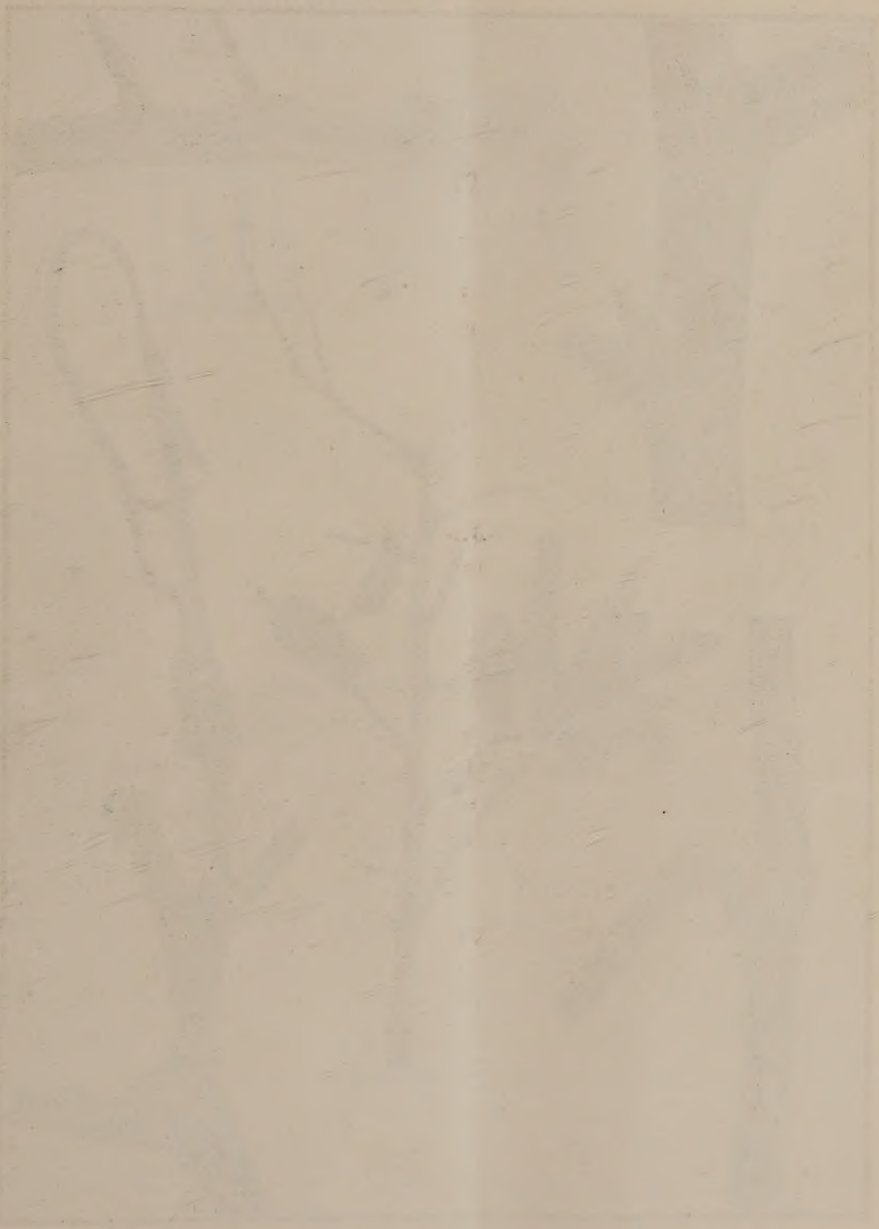

THE LIME TREE BORER

(Chelidonium cinctum)

1. Egg laid by lime tree borer beetle.
2. Same enlarged.
3 & 4. Wood dust gathered round air-holes made by borer.
5. Cut made by larva in twig.
6. Gummy exudation following penetration by borer.
7. Twig withering as a result of tunnelling by borer.
8. Borer exposed in tunnel.